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VOL 2 NO.6

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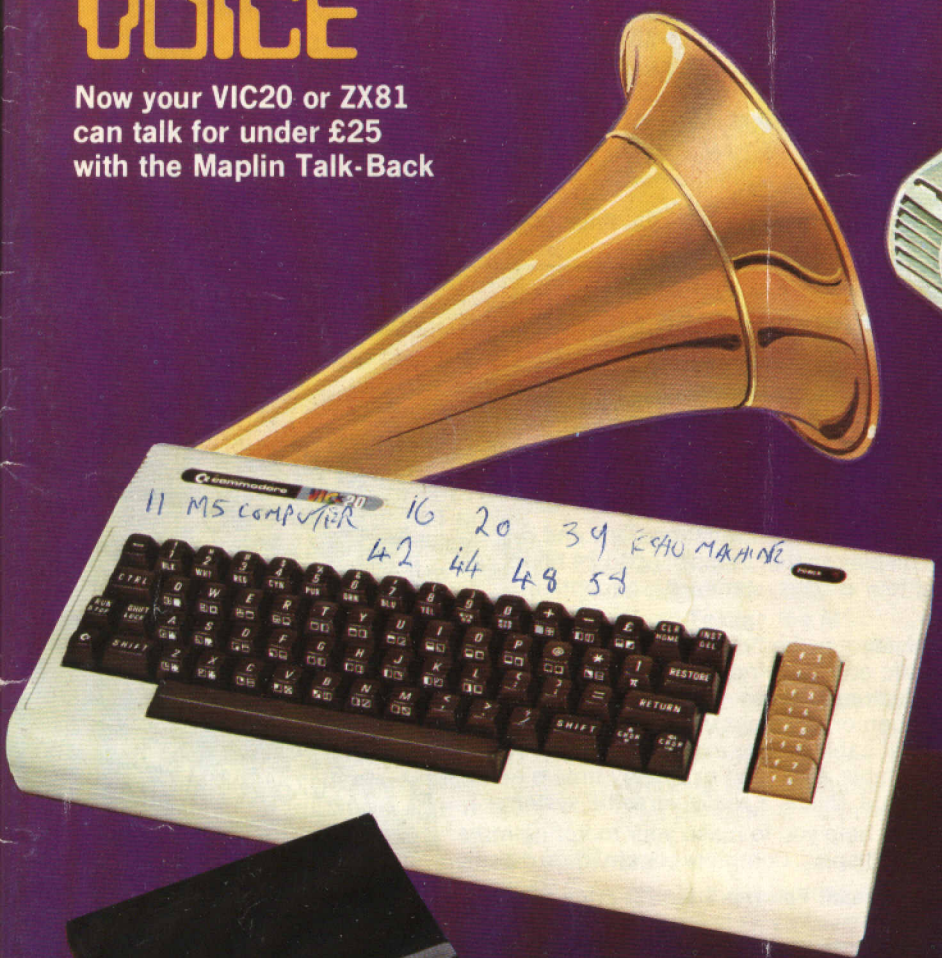

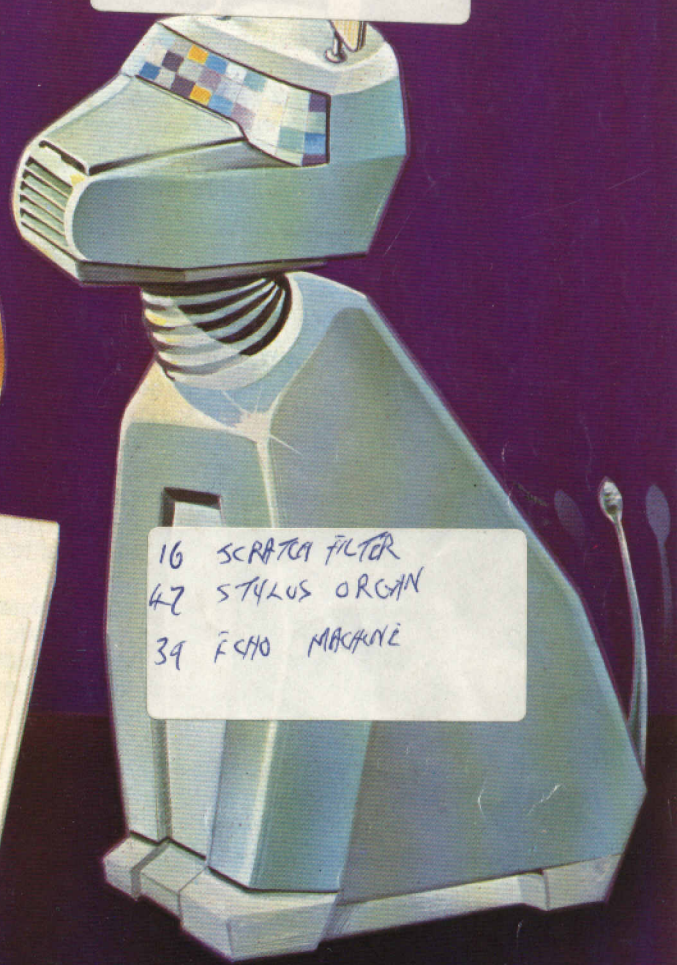

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VIC20 TALK-BACK

by Mark Brighton

- ★ **Allows speech to be easily included in programs**
- ★ **Allophone based system gives unlimited vocabulary**
- ★ **May be used with an unexpanded VIC — does not require large areas of memory**
- ★ **Speech output is direct to TV — no additional amplification needed**

This project is a 'plug-in' speech synthesizer for the VIC20, enabling the computer to 'talk' to the user in response to any programmed input. The synthesizer uses a system where words are put together from allophones, the basic 'building block' sounds of speech. In this way the sixty-four allophones available from this synthesizer can be strung together to form any English word or phrase, thus avoiding the need for several EPROMS each containing a limited vocabulary, as used by some speech synthesis systems.

The synthesizer is under complete program control, and can therefore be used for any application, from remote I/O operations to making games sound more realistic, depending on the program used.

Circuit Description

This circuit is built around the SP-0256 speech processor chip, an N channel MOS device incorporating the following functions:

1. A programmable digital filter which simulates the human voice tract.
2. A 16K ROM which contains the data for the 64 allophones.
3. A micro controller which controls the flow of speech data to the filter and the linking of allophones to produce words.
4. A pulse width modulator. This creates a digital speech output.

The speech processor is used by setting up an address on lines A0 to A5, to define one of 64 speech entry points, and pulsing $\overline{ALD}$ low to speak.

These address lines are connected, via a latch (IC1), to the address lines A0 to A5 on the VIC. The latch is enabled by

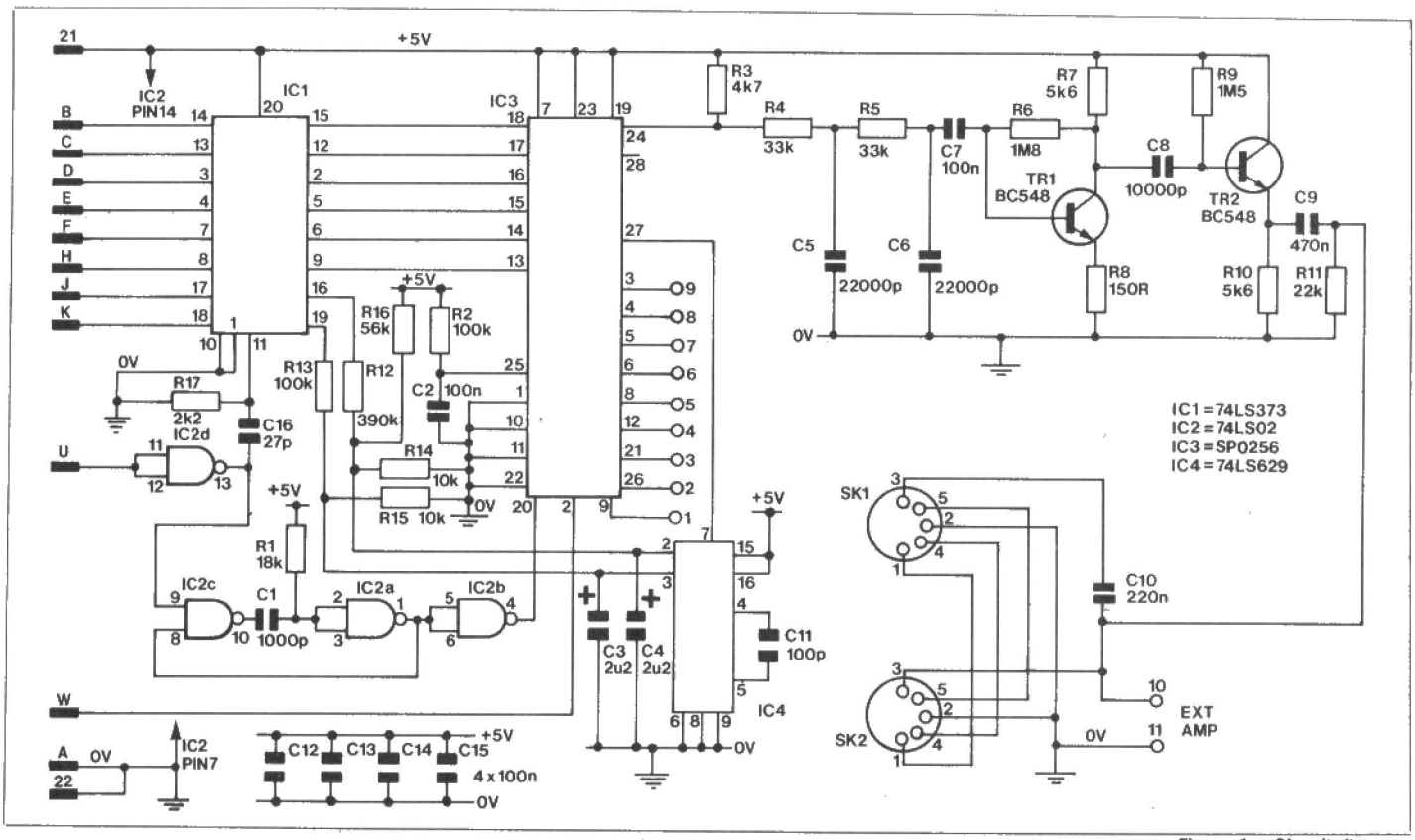
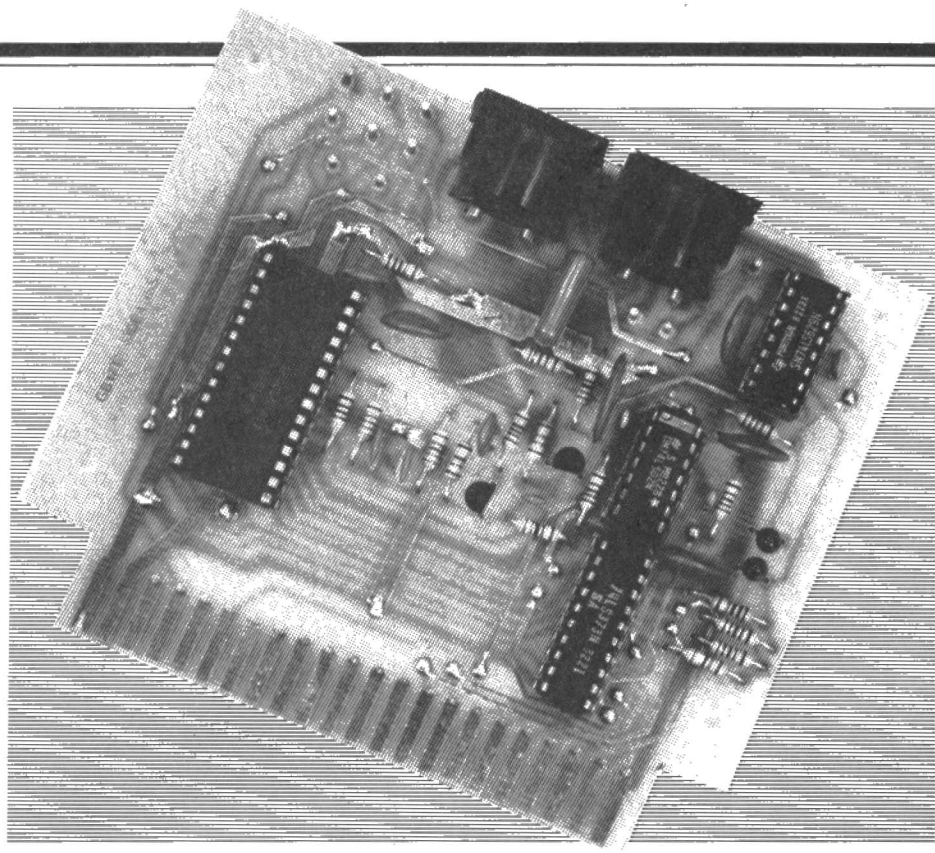


Figure 1. Circuit diagram.



IC2a when a block select pulse (I/O 3) is present, setting the speech entry points between 39936 and 39999.

IC2 forms a monostable that delays the block select pulse which enables the speech processor chip after the address set up on A0 to A5 is latched into IC1.

R5, C5 and C6 form a 5kHz low pass filter that converts the pulse modulated output of IC3 to an analogue signal. This is then amplified by TR1 and TR2. TR2 is a low output impedance emitter follower stage, which drives the VIC modulator.

IC4 is a voltage controlled oscillator, and provides the clock for IC3. The nominal frequency of this oscillator is set by C11 and R16 respectively. C3 and C4 prevent an abrupt change in clock frequency, and hence speech frequency, while R14 and R15 provide a discharge path for the capacitors.

The following status and control signals are provided on the board for ease of use and possible future expansion:

1. Veropin 1 is connected to $\overline{LRQ}$ on IC1, and is a logic 1 output while the speech processor is busy. This signal is

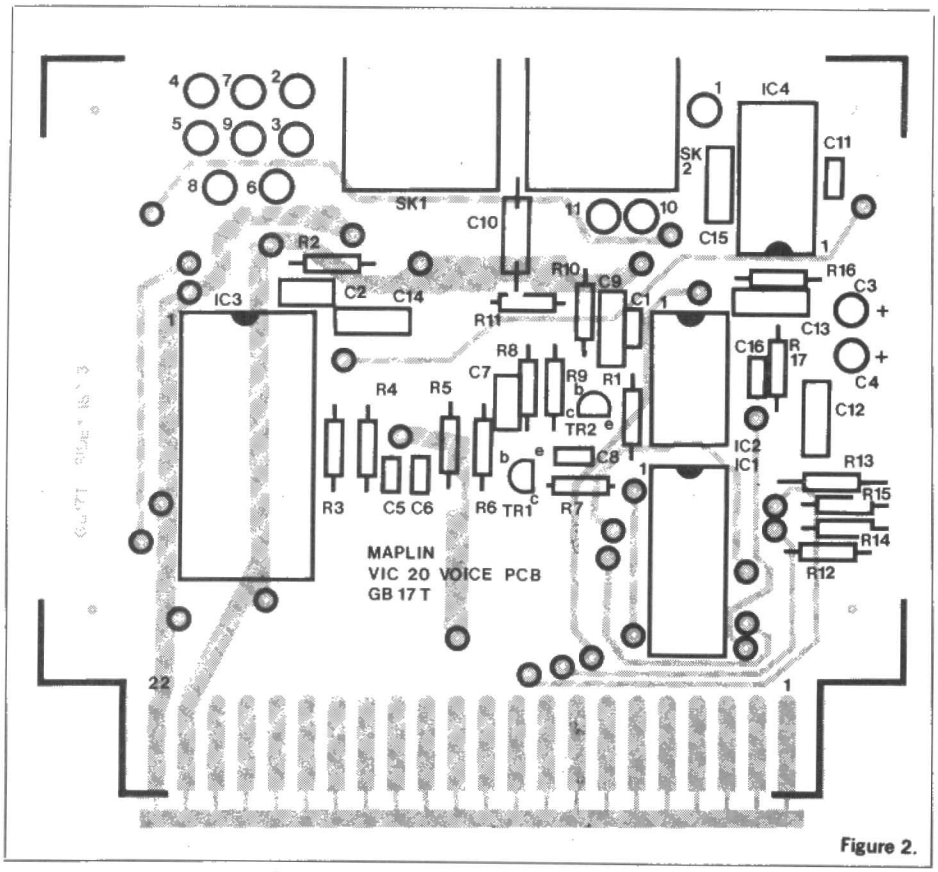


Figure 2.

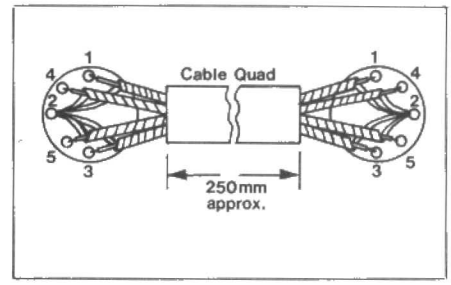


Figure 3.

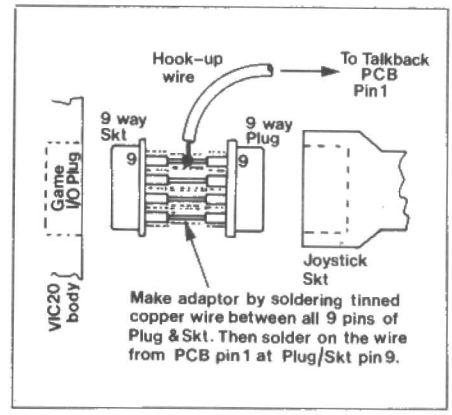


Figure 4.

connected, via PL1, to the paddle port on the VIC.

2. The RESET pin on IC1 is connected to the $\overline{NMI}$ line on the VIC. The chip is therefore reset when the VIC 'restore' key is pressed and an $\overline{NMI}$ pulse is generated.

3. Veropins 2 to 9 are serial address, data and control lines which can be used by an external speech ROM.

Use

To use the speech synthesizer, the correct addresses for each allophone in the phrase to be spoken must be POKEd

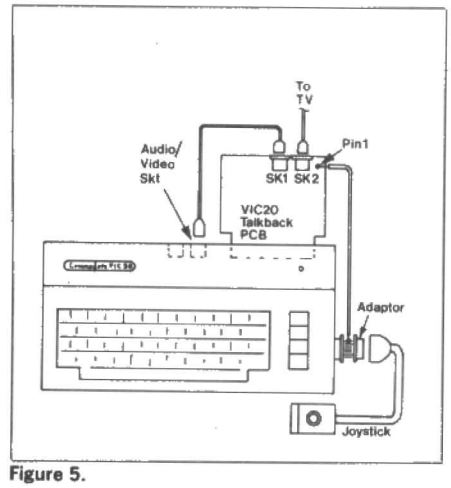


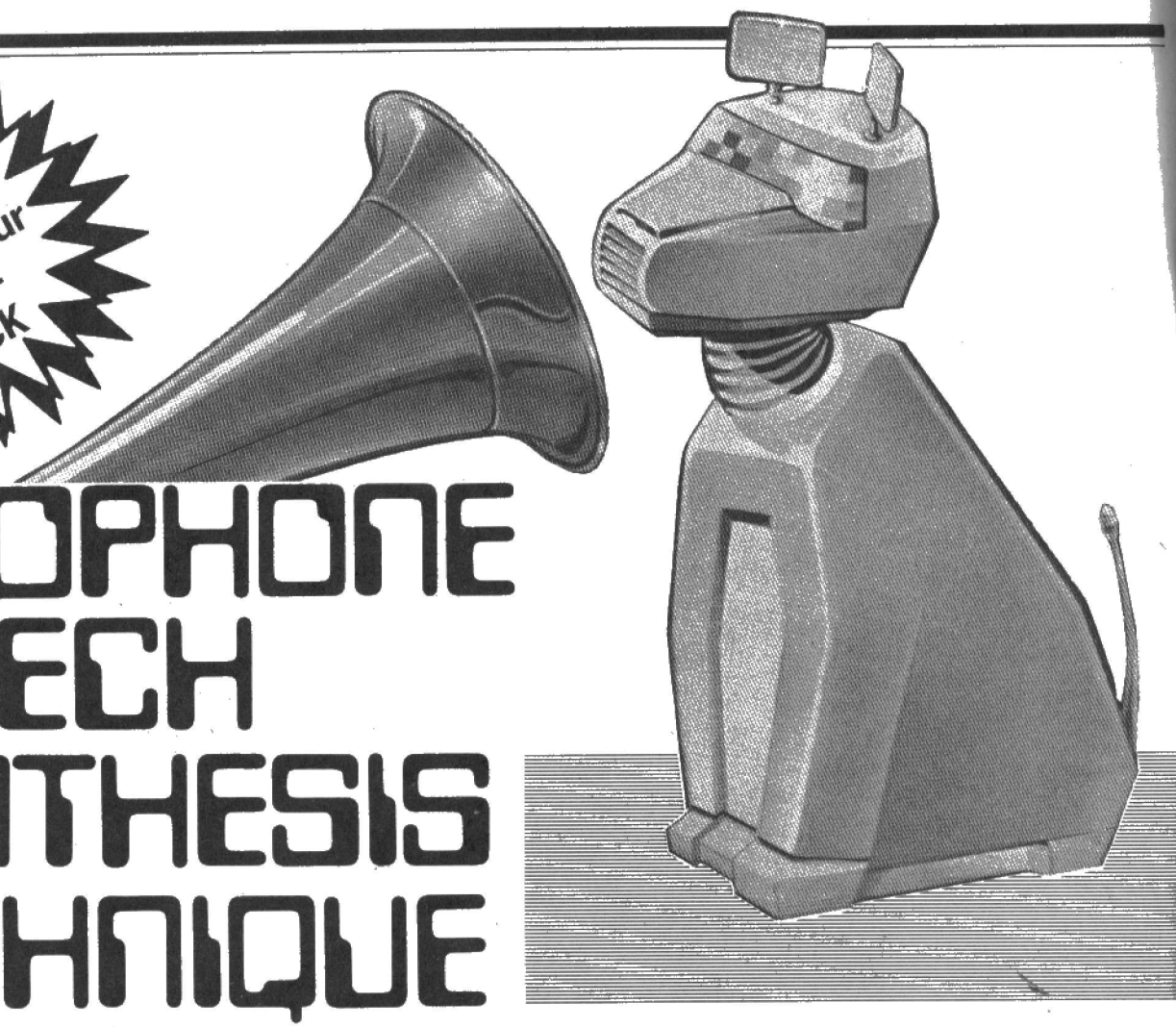
Figure 5.

sequentially with a value between 0 and 255 (the speech chip is linked to the address lines of the VIC, not the data lines, so the value POKEd may be any legal quantity).

One of the easiest ways to do this is to use a data statement where each number corresponds to an offset from the base address, i.e. the address of the first allophone stored in the speech

continued on page 7

Make the best use of your TALK-BACK



ALLOPHONE SPEECH SYNTHESIS TECHNIQUE

by Janet May

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Introduction

The General Instrument allophone speech synthesis technique is easy to use, has a remarkably low bit rate, and allows the user to synthesise any English word by concatenating individual speech sounds. Each allophone requires a six bit address. Assuming that speech contains ten to twelve allophones per second, allophone synthesis would require addressing less than 100 bits per second. Previous techniques have involved synthesising and storing entire words as units. The major disadvantage of this method is that, unless you want to use a very large memory, you are limited to a small vocabulary. For example, pulse code modulation (PCM), which is no more than digital recording, storage, and playback of speech waveforms, requires about 70 thousand data bits per second of speech. Another method, linear predictive coding (LPC), which predicts a speech sample from a weighted combination of previous samples, requires only one to two thousand bits per second to speech. Using this method, approximately 15-20 words can be stored in 16K bits of memory. While these methods require a large memory for a limited vocabulary, their big advantage is relatively high quality speech.

Allophone synthesis, on the other hand, has the major advantage of providing an unlimited vocabulary, since the stored units are not words, but individual speech sounds (allophones). The user merely has to become familiar with the speech sounds of English *(which are different from letters)* and the allophone symbols used to represent them. Another use for allophone synthesis is in a text-to-speech system in which the user inputs a string of text no different from what you are presently reading. The advantage of such a system is that the user does not have to learn the allophone symbols. Two sets of rules would be required: one which converts text to allophone symbols, and a second which converts those symbols to sounds. It is the second set of rules which we have already created and are discussing here.

One disadvantage of allophone synthesis, however, is that, although completely understandable, the speech quality is not as good as it is for PCM or LPC. The problem arises when concatenating the allophones to form words. This will be discussed further in the sections to follow.

	One-sound-to-many-letter representation	Many-sound-to-one-letter representation
Vowels	meat feet Pete people penny	vein foreign deism deicer geisha
Consonants	ship tension precious nation	although ghastly cough

Table 1 - Spelling Irregularities

Language

In order to successfully use a set of allophone sounds to synthesise words there are a few preliminary points which should be made about speech and language. First, there is no one-to-one correspondence between written letters and the sounds of a language; secondly, speech sounds are not discrete units as beads on a string are; and lastly, speech sounds are acoustically different depending on what position in a word they occur, and what sounds precede or follow them.

The first of these is a problem which a child encounters when learning how to read. Each sound in a language may be represented by more than one letter, and conversely, each letter may represent more than one sound. (See the examples in Table 1). Because of these spelling irregularities we must be very careful to remember to think in terms of *sounds* not letters, when dealing with speech.

The second point to be made concerns segmentation of the speech signal. An adult who has learned how to read usually thinks of the acoustic stream of speech as a string of discrete sounds which he calls by their letter names. But, in fact, speech is a continuously varying signal which cannot be easily broken into distinct sound-size units. For example, if one attempts to extract the b sound from the word bat by taking successively larger chunks of the acoustic signal from the beginning of the word, one at first hears a non-speech noise, and then at some point hears ba. In other words, there is no point at which the b sound can be heard in isolation; one hears either a non-speech noise or the syllable ba.

Finally, the most important point to make for users of an allophone set, is that the acoustic signal of a speech sound may differ depending on whether it occurs in word-initial or word-final position; or in the environment of a vowel which is articulated in the front or back of the oral cavity, a long or short vowel, or a voiced or voiceless consonant. For example, the initial p in pop will be acoustically different from the p in spy,

		Labial	Labio-Dental	Inter-Dental	Alveo-Lar	Palatal	Velar	Glottal
Stop:	Voiceless	PP			TT		KK	
	Voiced	BB			DD		GG	
Fricatives:	Voiceless	WH	FF	TH	SS	SH		HH
	Voiced		VV	DH	ZZ	ZH*		
Affricates:	Voiceless					CH		
	Voiced					JH		
Nasals:	(Voiced)	MM			NN		NG*	
Resonants:	(Voiced)	WW			RR,LL	YY		

Labial: Upper and Lower Lips Touch or Approximate
Labio-Dental: Upper Teeth and Lower Lip Touch
Inter-Dental: Tongue Between Teeth
Alveolar: Tip of Tongue Touches or Approximates Alveolar Ridge (just behind upper teeth)
Palatal: Body of Tongue Approximates Palate (roof of mouth)
Velar: Body of Tongue Touches Velum (posterior portion of roof of mouth)
Glottal: Glottis (opening between vocal cords)

*These do not occur in word-initial position in English.
**Examples of these phonemes in word context can be found in Table 5.

Table 2 - Consonant Phonemes of English**

	Front	Central	Back
High	YR		
	IY		UW#
	IH*		UH*#
Mid	EY	ER	OW#
	EH*	AX*	OY#
	XR		
Low	AE*	AW#	AO*#
		AY	OR#
*Short Vowels		AR	
#Rounded Vowels		AA*	

Table 3 - Vowel Phonemes of English

	(Silence)			(Voiced Fricat.)	
PA1	PAUSE	10MS	/VV/	vEST	190MS
PA2	PAUSE	30MS	/DH1/	thEY	290MS
PA3	PAUSE	50MS	/DH2/	thEY	120MS
PA4	PAUSE	100MS	/ZZ/	zOO	210MS
PA5	PAUSE	200MS	/ZH/	AzURE	190MS
	(Short Vowels)			(Voiceless Fricat.)	
x/IH/	SiT	70MS	x/FF/	fOOD	150MS
x/EH/	eND	70MS	x/TH/	thIN	180MS
x/AE/	HaT	120MS	x/SS/	VEsT	90MS
x/UH/	BooK	100MS	/SH/	shIP	160MS
x/AO/	auGHT	100MS	/HH1/	hE	130MS
x/AX/	SuCCEED	70MS	/HH2/	hOE	180MS
x/AA/	HoT	100MS	/WH/	whIG	200MS
	(Long Vowels)			(Voiced Stop Cons.)	
/IY/	See	250MS	/BB1/	bUSINESS	50MS (SOFT)
/EY/	BeiGE	280MS	/BB2/	bUSINESS	50MS
/AY/	SKy	260MS	/DD1/	COULd	70MS
/OY/	Boy	420MS	/DD2/	dO	160MS
/UW1/	To	100MS	/GG1/	gUEST	80MS
/UW2/	To	260MS	/GG2/	gOT	50MS
/OW/	Beau	240MS	/GG3/	WIg	160MS
/AW/	ouT	370MS			
/EL/	SADDle	190MS		(Voiceless Stop Cons.)	
	(R — Coloured Vowels)		/PP/	pOW	210MS
/ER1/	Fir	160MS	/TT1/	PARt	100MS
/ER2/	Fir	300MS	/TT2/	tO	140MS
/OR/	STore	330MS	/KK1/	cAN'T	160MS
/AR/	ALarM	290MS	/KK2/	SkY	190MS
/YR/	CLear	350MS	/KK3/	cOMB	120MS
/XR/	REPair	360MS		(Affricate)	
	(Resonants)		/CH/	chURCH	190MS
/WW/	wOOL	180MS	/JH/	DOdgE	140MS
/RR1/	rURAL	170MS		(Nasal)	
/RR2/	BrAIN	120MS	/MM/	mILK	180MS
/LL/	lAKE	110MS	/NN1/	THIn	140MS
/YY1/	yES	130MS	/NN2/	nO	190MS
/YY2/	yES	180MS	/NG/	AnCHOR	220MS

x — These allophones can be doubled

Table 4. Allophones

and may be different from the final p in pop. Furthermore, the ear will perceive the same acoustic signal differently depending on what sounds precede or follow it. The word cot can be made to sound like cod by lengthening the duration of the O, and conversely, the word cod can be made to sound like cot by shortening the duration of the O.

Phonemes of English

It will be useful to know what the speech sounds of English are. The sounds of a language are called phonemes, and each language has a set of which is slightly different from those of other languages.

Table 2 contains a chart of all the consonant phonemes of English, and Table 3 all the vowel phonemes of English.

Consonants are produced by creating a constriction or complete occlusion in the vocal tract which produces an aperiodic sound source. If the vocal cords are vibrating at the same time, as in the case of the voiced fricatives VV, DH, ZZ, and ZH (see Table 4) there are two sound sources: one which is aperiodic and one which is periodic.

Vowels are produced with a relatively open vocal tract and a periodic sound source (unless they are whispered) provided by the vibrating vocal cords. Vowels are classified according to whether the front or back of the tongue is high or low (see Table 3), whether they are long or short, and whether the lips are rounded or unrounded. In English all rounded vowels are produced in or near the back of the mouth (UW, UH, OW, AO, OR, AW).

It will be useful to remember that sounds which have features in common behave in similar ways. For example, the voiceless stop consonants PP, TT, and KK (see Table 2) require 50-80 msec of silence before them and the voiced stop consonants BB, DD and GG require 10-30 msec of silence before them. When you find a particular technique that works well with one sound, try using that same technique with similar sounds. For example, if you decide that KK1 sounds good before a front vowel (IY), use it before other front vowels (YR, IY, IH, EY, EH, XR, AE).

Allophones

So far we have been talking about phonemes, but in fact, a phoneme is an abstraction. It is the name given to a group of similar sounds in a language. Recall the statement that the phoneme PP will be acoustically different depending on whether it occurs in word-initial or word-final position, or after SS. Each of these different PPs are allophones of the phoneme PP. An allophone, therefore, is what occurs in the actual acoustic speech signal. A phoneme is the name of a group of related allophones. It is for this reason that our inventory of English speech sounds is called an allophone set.

How to use the allophone set

The allophone set (see Table 4) contains two or three versions of some phonemes. You may find that you need to use one allophone or a particular phoneme for word - or syllable - initial position and another for word - or syllable - final position. A detailed set of guidelines for using the allophones is given in Table 6. Note that these are suggestions, not rules.

DD2-AO-TT2-ER1	"daughter"
KK3-AX1-LL-AY-DD1	"collide"
SS-SS-IH-SS-TT2-ER1	"sister"
KK1-LL-AW-NN1	"clown"
SS-KK3-WW-XR	"square"
KK3-UH-KK1-IY	"cookie"
LL-EH-TT2-ER	"letter"
LL-IH-TT2-EL	"little"
AX1-NG-KK3-EL	"uncle"
KK1-AX1-MM-PP1-YY1-UW1-TT2-ER	"computer"
EH-KK1-SS-TT2-EH-EH-NN1-TT2	"extent"
TT2-UW2	"two"
AX1-LL-AR-MM	"alarm"
SS-KK3-CR	"score"
FF-ER2	"fir"

Table 5 - Examples of words made from Allophones

Silence

PA1 (10 ms) — before BB, DD, GG, and JH
PA2 (30 ms) — before BB, DD, GG, and JH
PA3 (50 ms) — before PP, TT, KK, and CH, and between words
PA4 (100 ms) — between clauses and sentences
PA5 (200 ms) — between clauses and sentences

Short Vowels

*/IH/ — sitting, stranded
*/EH/ — extent, gentlemen
*/AE/ — extract, acting
*/UH/ — cookie, full
*/AO/ — talking, song
*/AX/ — lapel, instruct
*/AA/ — pottery, cotton

Long Vowels

/IY/ — treat, people, penny
/EY/ — great, statement, tray
/AY/ — kite, sky, mighty
/OY/ — noise, toy, voice
/UW1/ — after clusters with YY: computer
/UW2/ — in monosyllabic words: two, food
/OW/ — zone, close, snow
/AW/ — sound, mouse, down
/EL/ — little, angle, gentlemen

R-Colored Vowels

/ER1/ — letter, furniture, interrupt
/ER2/ — monosyllables: bird, fern, burn
/OR/ — fortune, adorn, store
/AR/ — farm, alarm, garment
/YR/ — hear, earring, irresponsible
/XR/ — hair, declare, stare

Resonants

/WW/ — we, warrant, linquist
/RR1/ — initial position: read, write, x-ray
/RR2/ — initial clusters: brown, crane, grease
/LL/ — like, hello, steel
/YY1/ — clusters: cute, beauty, computer
/YY2/ — initial position: yes, yarn, yo-yo

Voiced Fricatives

/VV/ — vest, prove, even
/CH1/ — word-initial position: this, then, they
/CH2/ — word-final and between vowels: bathe, bathing
/ZZ/ — zoo, phase
/ZH/ — beige, pleasure

Voiceless Fricatives

*/FF/ —
*/TH/ — These may be doubled for initial position and used singly in final position
*/SS/ —
/SH/ — shirt, leash, nation
/HH1/ — before front vowels: YR, IY, IH, EY, EH, XR, AE
/HH2/ — before back vowels: UW, UH, OW, OY, AO, OR, AR
/WH/ — white, whim, twenty

Voiced Stops

/BB1/ — final position: rib; between vowels: fibber; in clusters: bleed, brown
/BB2/ — initial position before a vowel: beast
/DD1/ — final position: played, end
/DD2/ — initial position: down; clusters: drain
/GG1/ — before high front vowels: YR, IY, IH, EY, EH, XR
/GG2/ — before high back vowels: UW, UH, OW, OY, AX; and clusters: green, glue
/GG3/ — before low vowels: AE, AW, AY, AR, AA, AO, OR, ER; and medial clusters: anger; and final position: peg

Voiceless Stops

/PP/ — pleasure, ample, trip
/TT1/ — final clusters before SS: tests, its
/TT2/ — all other positions: test, street
/KK1/ — before front vowels: YR, IY, IH, EY, EH, XR, AY, AE, ER, AX; initial clusters: cute, clown, scream
/KK2/ — final position: speak; final clusters: task
/KK3/ — before back vowels: UW, UH, OW, OY, OR, AR, AO; initial clusters: crane, quick, clown, scream

Affricates

/CH/ — church, feature
/JH/ — judge, injure

Nasal

/MM/ — milk, alarm, ample
/NM1/ — before front and central vowels: YR, IY, IH, EY, EH, XR, AE, ER, AX, AW, AY, UW; final clusters: earn
/NN2/ — before back vowels: UH, OW, OY, OR, AR, AA
/NG/ — string, anger

*These allophones can be doubled.

Table 6. Guidelines for using the Allophones.

Decimal Address	Octal Address	Hex Address	Allophones	Sample Word	Duration
0	000	0	PA1	PAUSE	10MS
1	001	1	PA2	PAUSE	30MS
2	002	2	PA3	PAUSE	50MS
3	003	3	PA4	PAUSE	100MS
4	004	4	PA5	PAUSE	200MS
5	005	5	/OY/	Boy OY	420MS
6	006	6	/AY/	Sky Y	250MS
7	007	7	/EH/	End E	70MS
8	010	8	/KK3/	Comb C	120MS
9	011	9	/PP/	Pow P	210MS
10	012	A	/JH/	Dodge G	140MS
11	013	B	/NN1/	Thin N	140MS
12	014	C	/1H/	Sit I	70MS
13	015	D	/TT2/	To T	140MS
14	016	E	/RR1/	Rural R	170MS
15	017	F	/AX/	Succeed U	70MS
16	020	10	/MM/	Milk M	180MS
17	021	11	/TT1/	Part T	100MS
18	022	12	/DH1/	They TH	290MS
19	023	13	/IY/	See E	250MS
20	024	14	/EY/	Beige EI	280MS
21	025	15	/DD1/	Could ID	70MS
22	026	16	/UW1/	To O	100MS
23	027	17	/AO/	Aught AU	100MS
24	030	18	/AA/	Hot O	100MS
25	031	19	/YY2/	Yes YE	180MS
26	032	1A	/AE/	Hat A	120MS
27	033	1B	/HH1/	He H	130MS
28	034	1C	/BB/	Business BU	80MS
29	035	1D	/TH/	Thin TH	180MS
30	036	1E	/UH/	Book OO	100MS
31	037	1F	/UW2/	Food OO	260MS
32	040	20	/AW/	Out OU	370MS
33	041	21	/DD2/	Do D	160MS
34	042	22	/GG3/	Wig IG	140MS
35	043	23	/VV/	Vest V	190MS
36	044	24	/EG1/	Guest GU	80MS
37	045	25	/SH/	Ship S	160MS
38	046	26	/ZH/	Azure Z	190MS
39	047	27	/RR2/	Brain R	120MS
40	050	28	/FF/	Food F	150MS
41	051	29	/KK2/	Sky K	190MS
42	052	2A	/KK1/	Can't C	160MS
43	053	2B	/ZZ/	Zoo Z	210MS
44	054	2C	/NG/	Anchor N	220MS
45	055	2D	/LL/	Lake L	110MS
46	056	2E	/WW/	Wool W	180MS
47	057	2F	/XR/	Repair R	360MS
48	060	30	/WH/	Whig W	200MS
49	061	31	/YY1/	Yes Y	130MS
50	062	32	/CH/	Church C	190MS
51	063	33	/ER1/	Fir IR	160MS
52	064	34	/ER2/	Fir ERR	300MS
53	065	35	/CW/	Beau AU	240MS
54	066	36	/DH2/	They TH	240MS
55	067	37	/SS/	Vest S	90MS
56	070	38	/NN2/	No N	190MS
57	071	39	/HH2/	Hoe H	180MS
58	072	3A	/OR/	Store OR	330MS
59	073	3B	/AR/	Alarm A	290MS
60	074	3C	/YR/	Clear R	350MS
61	075	3D	/EG2/	Got G	40MS
62	076	3E	/EL/	Saddle L	190MS
63	077	3F	/BB2/	Business B	50MS

Allophone Address Table.

For example, DD2 sounds good in initial position and DD1 sounds good in final position, as in "daughter" and "collide". (See Table 5 for instructions on how to create all the sample words mentioned in this section). One of the differences between the initial and final versions of a consonant is that an initial version may be longer than the final version. Therefore, to create an initial SS, you can use two SSs instead of the usual single SS at the end of a word or syllable, as in "sister". Note that this can be done with TH, and FF, and the inherently short vowels (to be discussed below), but with no other consonants. You will want to experiment with some consonant clusters (strings of consonants such as str, cl) to discover which version works best in the cluster. For example KK1 sounds good before LL as in "clown", and KK2 sounds good before WW as in "square". One allophone of a particular phoneme may sound better before or after back vowels and another before or after front vowels. KK3 sounds good before UH and KK1 sounds good before 1y, as in "cookie". Some sounds (PP, BB, TT, DD, KK, GG, CH and JH) require a brief duration of silence before them. For most of these, the silence has already been added but you may decide you want to add more. Therefore, there are several pauses included in the allophone set varying from 10-200 msec. To create the final sounds in the words "letter" and "little" use the allophones ER and EL. Remember that you must always think about how a word sounds, not how it is spelled. For example, the NG allophone obviously belongs at the ends of the words "sing" and "long", but notice that the NG sound is represented by the letter N in "uncle". And remember that some sounds may not even be represented in words by any letters, as the YY in "computer".

As mentioned earlier there are some vowels which can be doubled to make longer versions for stressed syllables. These are the inherently short vowels IH, EH, AE, AX, AA and UH. For example, in the word "extent" use one EH in the first syllable, which is unstressed and two EHs in the second syllable which is stressed. Of the inherently long vowels there is one, UW, which has a long and short version. The short one, UW1, sounds good after YY in computer. The long version, UW2, sounds good in monosyllabic words like "two". Included in the vowel set is a group called R-coloured vowels. These are vowel + R combinations. For example, the AR in "alarm" and the OR in "score". Of the R-colored vowels there is one, ER, which has a long and short version. The short version is good for polysyllabic words with final ER sounds like "letter", and the long version is good for monosyllabic words like "fir". One final suggestion is that you may want to add a pause of 30-50 msec between word, when creating sentences, and a pause of 100-200 msec between clauses.

VIC20 TALKBACK continued from page 3

chip (this base address has been set at 39936, by using the I/O 3 block select pulse on the edge connector). An example of this method is shown in Listing 1.

A form of tonal inflection is also provided. To raise the tone of a given allophone, add 64 to the offset from the base address. To lower the tone, add 128. Best results will be achieved by experimentation.

```
1     POKE 37139,0 : POKE 37154,127 : REM SET
                     UP DDR FOR PADDLE PORT
5     CHIP = 39936
10    FOR NUMBER = 1 TO 23 :
      READ SPEECH :
      POKE CHIP+SPEECH,0 :
      WAIT 36872,128 :
      NEXT NUMBER
20    POKE 37154,255 : REM RESET DDR FOR
                              KEYBOARD
500   DATA     16,90,73,109,76,75,64,55,9,83,
               114,64,119,76,75,93,79,119,55,
               6,43,51,0
```

Construction

Referring to figure 2 and the parts list, assemble the project as follows: First, bend and insert resistors R1 to R17, and fit capacitors C1 to C16. Insert all veropins and IC sockets, TR1 and TR2. Solder all components into place, clean and inspect the track for dry joints and short circuits, and fit the ICs into the holders. The connector leads are to be used with the plug-in board, and these should be wired to the plugs provided as shown in figures 3 and 4.

Testing

Using a meter switched to resistance, measure between +5V and 0V on the board, to ensure that no shorts exist. With the computer switched off, plug the board into the memory expansion connector, and PL1 into the control port (joystick socket) on the side of the VIC. PL2 is plugged into the modulator socket on the VIC, and PL3 into SK1 on the speech synthesizer board. The VIC modulator is then plugged into SK2 on the synthesizer (see figure 5).

Switch the computer on. If the computer fails to display the 'CBM BASIC' and 'READY' messages switch off immediately and re-check all component placings and connections.

VIC20 TALKBACK PARTS LIST

Resistors: All 0.4W 1% Metal Film

R1	18k		(M18K)
R2,13	100k	2 off	(M100K)
R3	4k7		(M4K7)
R4,5	33k	2 off	(M33K)
R6	1M8		(M1M8)
R7,10	5k6	2 off	(M5K6)
R8	150R		(M150R)
R9	1M5		(M1M5)
R11	22k		(M22K)
R12	390k		(M390K)
R14,15	10k		(M10K)
R16	56k		(M56K)
R17	2K2		(M2K2)

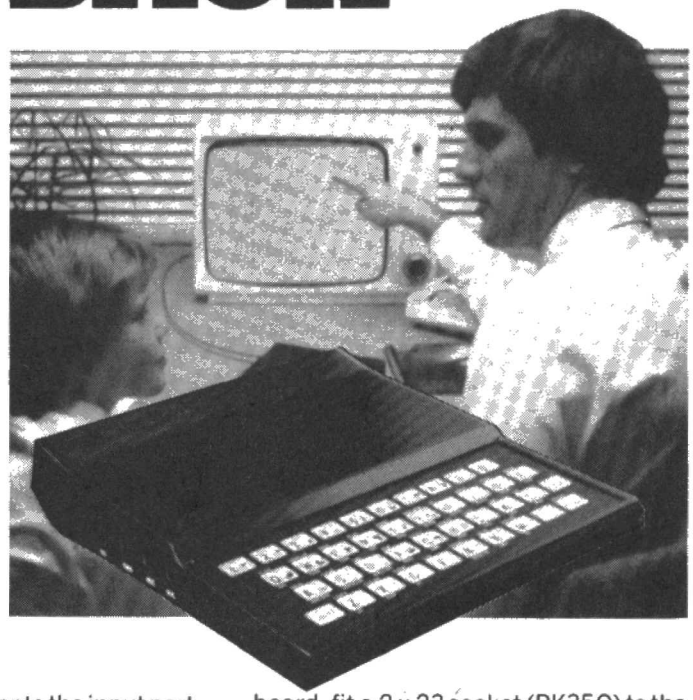
Capacitors			
C1	1000pF Ceramic		(WX68Y)
C2,7	100nF Minidisc	2 off	(YR75S)
C3,4	2u2F Tantalum	2 off	(WW62S)
C5,6	22.000pF Ceramic	2 off	(WX78K)
C8	10.000nF Ceramic		(WX77J)
C9	470nF Minidisc		(YR76H)
C10	220nF Polyester		(BX78K)
C11	100pF Ceramic		(WX56L)
C12-15 inc.	100nF Disc Ceramic	4 off	(BX03D)
C16	27pF Ceramic		(WX49D)

Semiconductors			
TR1,2	BC548	2 off	(QB73Q)
IC1	74LS373		(YH15R)
IC2	74LS02		(YF02C)
IC3	SP0256		(QY50E)
IC4	74LS629		(WH02C)

Miscellaneous			
	14 Pin DIL Skt		(BL18U)
	16 Pin DIL Skt		(BL19V)
	20 Pin DIL Skt		(HQ77J)
	28 Pin DIL Skt		(BL21X)
	Veropin 2141	(1 Pkt)	(FL21X)
	Track Pin	(1 Pkt)	(FL82D)
SK1,2	PC Din Skt 5-Pin A	2 off	(YX91Y)
	PCB		(GB17T)
	D-Range 9-Way Plug		(RK60Q)
	D-Range 9-Way Skt		(RK61R)
	DIN Plug 5-Pin A	2 off	(HH27E)
	Cable Quad	1m	(XR23A)
	Hook-up Wire	1m	(BL00A)

A complete kit of all parts is available for this project.
Order As LK00A (VIC Talkback Kit) Price £24.95

ZX 81 TALK-BACK



by Dave Goodman

- ★ **Add speech to your programs**
- ★ **Allophone set provides unlimited vocabulary**
- ★ **Plugs directly into expansion socket or motherboard**
- ★ **Entry from simple PEEK and POKE in BASIC**
- ★ **Audio output to external amplifier or our 'Sound-on-TV'**

For many years considerable research and development has been done in the field of human speech synthesis. All languages have their own complex speech sounds, or ALLOPHONES, which are strung together to form recognisable words. The SHAW alphabet gives an indication of speech sounds, as many schoolchildren are probably aware.

Simple words like 'cad' use the letters 'see', 'ae', and 'tee'. Stringing these allophones together will produce the sound 'seat', not at all like 'cat', so letters of the alphabet are pronounced differently according to where they are used!

General Instruments' SPO256 Orator-Speech Processor makes use of the allophone system by storing sounds, with instructions, in 16K ROM. A Microtroller control data flow from ROM to a digital filter where speech elements are linked together, along with pitch and amplitude information. The resulting information is pulse width modulated, producing a digital output which has to be low pass filtered to produce recognisable speech.

Sixty-three allophones are available for use, and by concatenating individual sounds, reproduction of entire word lengths is possible. This is very flexible, although speech quality is not as good as systems where complete words are stored.

Circuit Description

Address lines AØ to A15 are decoded by IC1, 2 and 3 to give a memory-mapped 'PORT' address of 16417. This address has not been allocated to the working system of the ZX81, and as it also has a RAM location it is ideal for use in this application. Writing to this address (POKE 16417) places a negative pulse on IC5 pin 20 Address Load input. Data written into IC5, on pins 13 to 18, is then loaded onto the input port, where it is processed to give speech output on pin 24. The circuitry of TR1 forms a low pass filter, to remove any H.F. content from the speech, and the resultant signal is amplified to a usable level of 100-500mV with the output on pin 1 (pin 2 is the 0V or screen). Obviously, the computer can supply data at a far greater rate than it can be processed by IC5, so pin 8 (standby) is used to enable IC6 if the 'PORT' address is read (PEEKed).

With suitable programming IC6 will place DØ to D8 to binary 0 and a software loop will prevent further data being entered to IC5 until the standby output resets. One problem, however, becomes apparent when the system is first switched on; R1 and C7 reset the SPO256 and pin 8 goes low. While the ZX81 CPU is resetting RAM locations, IC6 is enabled and data is prematurely entered, causing the computer to crash. IC4b, C13, and D1 hold IC6 pins 1 and 19 high to prevent this happening. Entering the command NEW can also cause this problem, but not if you are using 1 to 16K RAM. C13 may need to increase in value if larger RAM is used, and this is a subject for experimentation.

Construction

Insert all 48 track pins through the holes marked with a circle, and solder them on both sides of the PCB. Fit resistors R1 to R7; if using the new 1% resistors with 5 band colour codes make sure that the values are correct. Finally, fit all capacitors, noting the polarity marking on C10. Do not insert the ICs yet. Solder all components to the PCB, clean, and inspect your work. Many faults can be cleared by using thinners and a stiff brush to remove all flux and solder splashes from the PCB.

If you do not possess a motherboard, fit a 2 x 23 socket (RK35Q) to the edge connector and solder all pins. Otherwise plug the module into your ZX81.

Testing

Apply power. If all is well the cursor will appear as normal. Use a voltmeter to check that the 0V and +5V rails are correct on the PCB. Switch off and insert the six ICs into their sockets. Reapply power. The cursor should appear again. You will need either an external amplifier or our sound/video project with connections to pins 1 and 2 on the module. Turn the amplifier or TV volume control to an acceptable level and type in POKE 16417, 197 followed by NEWLINE. You should hear the allophone 'oy' and a continuous 'e' sound. Type POKE 16417, Ø NEWLINE and the sound will cease. Thus far, all should be well. Now enter program 1 and run it. Various prompts and directions appear during the program run and allophone sounds, not words, will be heard. Run the program several times to familiarise yourself with each sound and code number.

Using the Talkback

If you refer to the Sinclair Manual page 178, you will see that address 16417 is not used by the working system. Fortunately this address, being part of the memory map, has a location in RAM which makes it ideal for use a a 'PORT'. Data POKEd to this address is read by the SPO256 chip, so the numbers entered must range from 192 to 255 to suit.

Table 1 gives a list of numbers and their equivalent allophone sound. Also shown is a list of ZX81 characters corresponding to each number and allophone. If a word, like COMPUTER, is phonetically split into a series of vowels

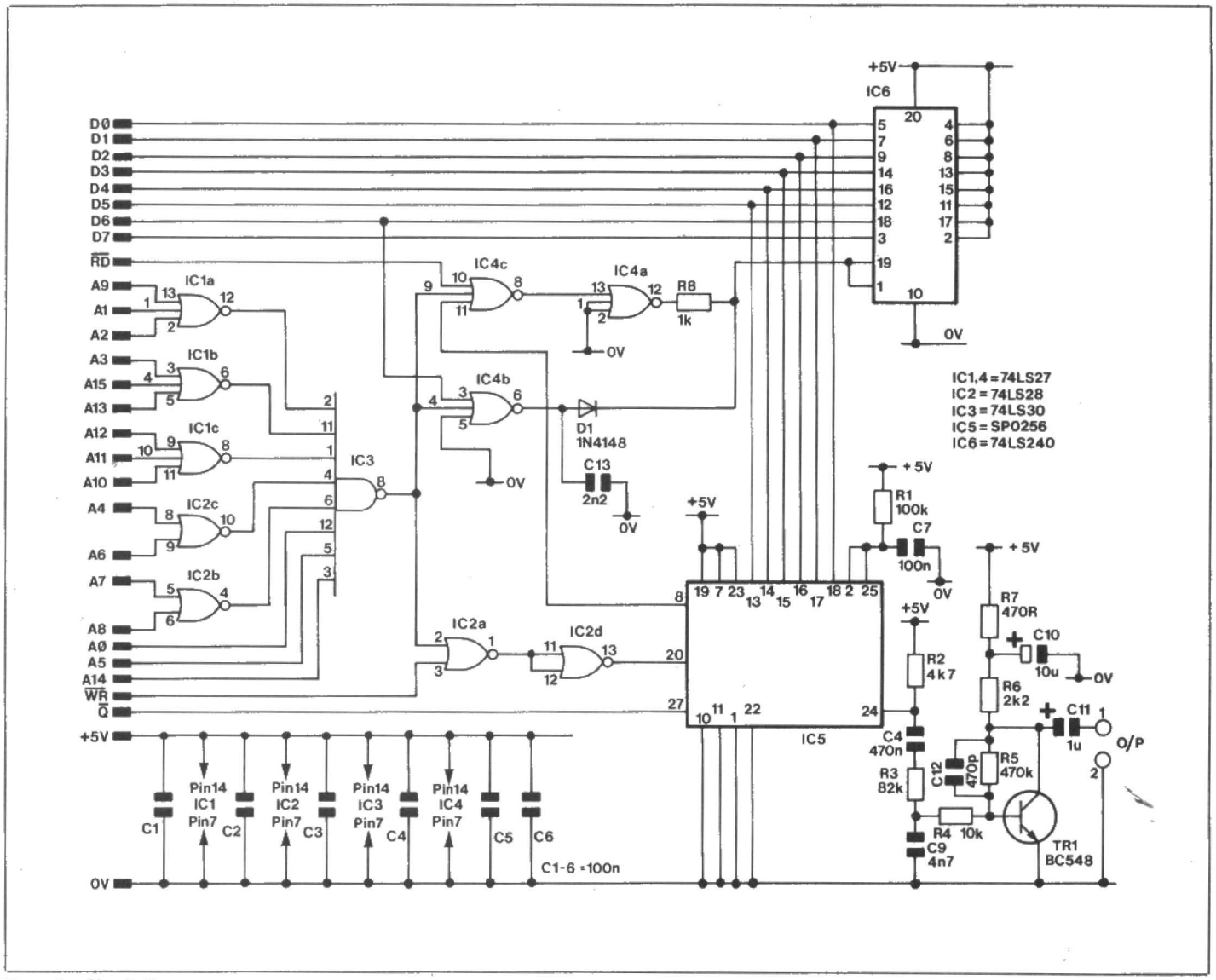


Figure 1. Circuit diagram.

and consonants the allophone equivalent will be something like this:

WORD	ALLO-PHONE	CODE	CHR$
C	KER	233	DIM
O	AA	216	**
M	MM	208	SQR
P	PP	201	TAN
U	YUH	241	LET
U	OOW	214	CHR$
T	TT2	205	LN
ER	ERR	241	POKE

The SP0256 has 63 allophones, five of which are pauses of different duration, which leaves 58 to span the range of the English language. Because of this limitation compromises have to be made with pronunciation, but in practise it is not a real problem as long as you do not mind your computer speaking with an American accent!

The letter c in computer does not sound like 'see', but 'k' as in kite. A short pause, e.g. code 194 (50ms) inserted between C and computer enhances the C, as can be heard in program 2. If you ran the test program, you will have heard each allophone spoken, and be already familiar with the sounds available, so now enter program 2.

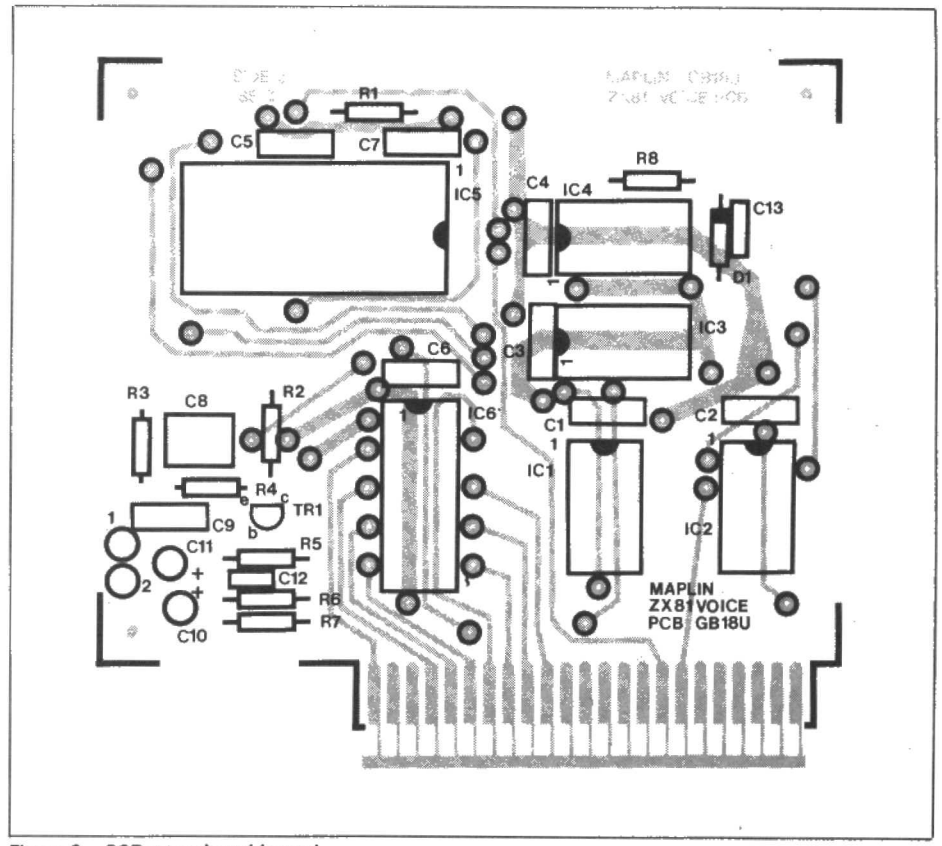


Figure 2. PCB artwork and legend.

CHR$	CODE	ALLOPHONE	CHR$	CODE	ALLOPHONE			
""	192	PAUSE 10ms	CHR$	214	OOW	FOR	235	ZER
AT	193	PAUSE 30ms	NOT	215	AO	GOTO	236	NA
TAB	194	PAUSE 50ms	**	216	AA	GOSUB	237	LL
CODE	196	PAUSE 200ms	OR	217	YE	INPUT	238	WW
VAL	197	OY	AND	218	AE	LOAD	239	RE
LEN	198	AY	<=	219	HH1	LIST	240	WH
SIN	199	EH	>=	220	BU	LET	241	YUH
COS	200	KK3	<>	221	TH	PAUSE	242	CH
TAN	201	PP	THEN	222	UO	NEXT	243	ERE
ASN	202	JH	TO	223	UOO	POKE	244	ERR
ACS	203	NN	STEP	224	OU	PRINT	245	UO
ATN	204	1H	LPRINT	225	DD2	PLOT	246	DH2
LN	205	TT2	LLIST	226	GG	RUN	247	SS
EXP	206	RR1	STOP	227	VE	SAVE	248	NNN
INT	207	AX	SLOW	228	GU	RAND	249	HER
SQR	208	MM	FAST	229	SSH	IF	250	OR
SGN	209	TT1	NEW	230	SZ	CLS	251	AR
ABS	210	DH1	SCROLL	231	R	UNPLOT	252	YR
PEEK	211	IY	CONT	232	FF	CLEAR	253	GGG
USR	212	EY	DIM	233	KER	RETURN	254	EL
STR$	213	DD1	REM	234	KU	COPY	255	BB

TABLE 1

The technique used in this program relies on placing allophone code numbers as CHR$ in line 1 after the REM statement. Altogether there are 18 CHR$ in this line, including pauses. The first address after REM is 16514, so each character has its own address up to 16532. The value of each address is POKEd into variable A, this being the PORT address of the speech processor, and line 1 is scanned, a character at a time, by line 10.

A software loop is set up by line 25 to allow time for each allophone to be spoken before continuing with the next instruction. Try removing line 25 from the program and listening to the difference.

Maybe you have your own routines for POKEing numbers into port locations, so I won't go into programming techniques on the ZX81. Needless to say, if using this method the address must be found for the first character to be read after REM, otherwise your program may crash. Some of the allophone CHR$ must be entered in command word mode. One way of doing this is to first enter THEN (shift CHR$) to change the cursor from L to K, and then enter the command word. Step the cursor back to THEN and RUBOUT. Step the cursor forward past the command word, and continue with the next CHR$. Always add a space (192 or "") at the end of the character string or insert POKE 16417,Ø at the end of your program, otherwise speech will continue.

FOR-NEXT or PAUSE delays can be entered after the POKE 16417 command to slow down speech if you find that it talks too fast. Use codes 192 to 196 to add pauses between allophones where required. Previous sounds spoken can then be emphasised to suit the word formation, and speech made more intelligible.

Program 1.

```
1   REM TEST PROGRAM
2   LET A = 197
3   LET PORT = 16417
4   PRINT "PRESS NEWLINE "
5   IF INKEY$ = " " THEN GOTO 5
6   PRINT "ALLOPHONE ""OY"" WILL BE SPOKEN "
7   PAUSE 250
8   POKE PORT,A
9   POKE PORT,0
10  CLS
11  PRINT "NUMBER 197 TO 255 WILL BE DISPLAYED,
        AND THE ALLOPHONE SPOKEN."
12  PAUSE 500
13  FOR A = 197 TO 255
14  PRINT AT 10,14;A
15  POKE PORT,A
16  FOR B = 0 TO 10
17  NEXT B
18  POKE PORT,192
19  NEXT A
20  POKE PORT,192
21  PRINT AT 15,0;"PRESS NEWLINE TO REPEAT TESTS"
22  INPUT A$
23  CLS
24  GOTO 11
```

Program 2.

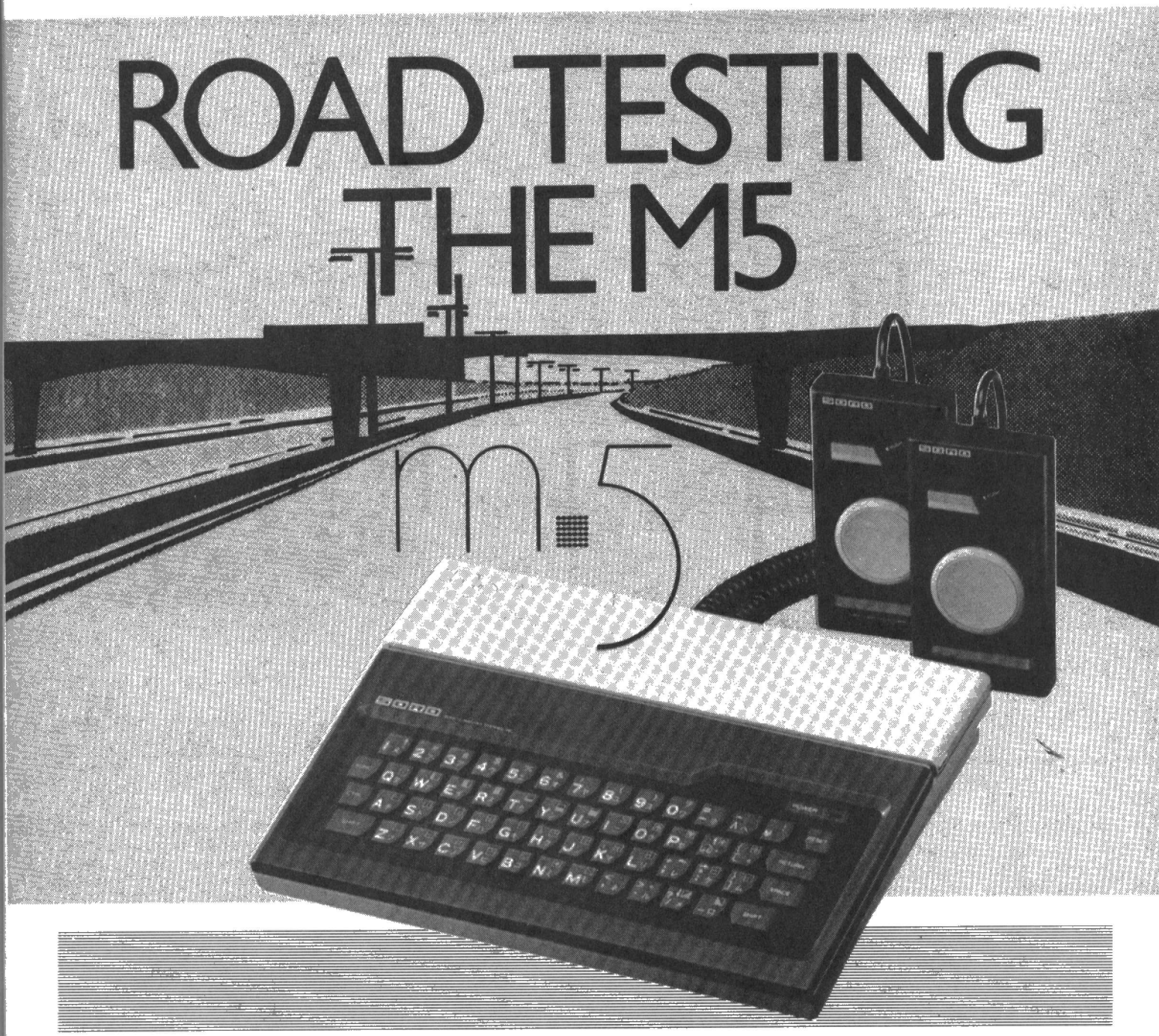
```
1   REM LEN "" AT AND SQR "" TAB USR DIM AT **
      SQR TAN LET CHR$ LN NEXT ""
3   LET A = 16417
5   LET B = 16514
7   REM NUMBER OF CHR$
10  FOR C = B TO (B+17)
15  POKE A,PEEK C
20  REM WORD LENGTH
25  IF PEEK A=0 THEN GOTO 25
30  NEXT C
35  CLS
40  PRINT " ""I AM A COMPUTER"" "
45  PRINT AT 18,0;"PRESS NEWLINE"
50  INPUT A$
60  GOTO 1
```

ZX81 TALKBACK PARTS LIST

Resistors — all 0.4W 1% metal film			
R1	100k		(M100K)
R2	4k7		(M4K7)
R3	82k		(M82K)
R4	10k		(M10K)
R5	470k		(M470K)
R6	2k2		(M2K2)
R7	470R		(M470R)
R8	1k		(M1K)
Capacitors			
C1-7 inc	100nF Disc Ceramic	7 off	(BX03D)
C8	470nF Polycarbonate		(WW49D)
C9	4n7F Polycarbonate		(WW26D)
C10	10uF 35V PC Electrolytic		(FF04E)
C11	1uF 35V Tantalum		(WW60Q)
C12	470pF Ceramic		(WX64U)
C13	2n2F Ceramic		(WX72P)
Semiconductors			
D1	1N4148		(QL80B)
TR1	BC548		(QB73Q)
IC1,4	74LS27	2 off	(YF18U)
IC2	74LS28		(YF19V)
IC3	74LS30		(YF20W)
IC5	SP0256		(QY50E)
IC6	74LS240		(YF87U)
Miscellaneous			
	14-pin DIL skt	4 off	(BL18U)
	20-pin DIL skt		(HQ77J)
	28-pin DIL skt		(BL21X)
	ZX81 voice pcb		(GB18U)
	Veropin 2141	1 pkt	(FL21X)
	Track Pin	1 pkt	(FL82D)

A set of parts is available to build the ZX81 Talkback.
Order As LK01B Price £24.95

ROAD TESTING THE M5



Within the last two years we have seen an explosion in the numbers of home computers competing for the money in our pockets. This year there will doubtless be many more. Most of them will be variations on the same theme, but one that we've been looking at recently really does seem to have something extra. It comes from the Japanese business microcomputer manufacturer Sord and is called the M5. It is in its graphics capabilities that the M5 really stands out, and we will look at that in depth later.

The M5 is a neat, lightweight and compact unit which has had to forego a full-size keyboard to remain compact. The keyboard has moving rubber keys, but they do have a nice feel and are as large as possible in the space provided. The worst thing about the keyboard is that the designers have seen fit to place the space and return keys next to each other, which can cause a lot of confusion at first.

Keyboard Functions

Fortunately the M5 boasts an excellent on-screen editor which allows you to move the cursor anywhere on the screen then change, add or delete characters at the desired point. As with most computers, each key (of which there are 55) has several functions.

Upper and lower case characters, a direct function call to BASIC, a graphics symbol and, because it is a Japanese machine, it also has a Japanese character set. The keyboard has 50 Japanese characters known as the "goju on", these are the fifty basic forms in the Japanese "alphabet" which has a total of 112 forms (a lot less than Chinese!) and the characters are displayed in the style known as Katakana. Since typing gobbledegook in Japanese has, however, a somewhat limited fascination, we'll move onto other things.

Making Connections

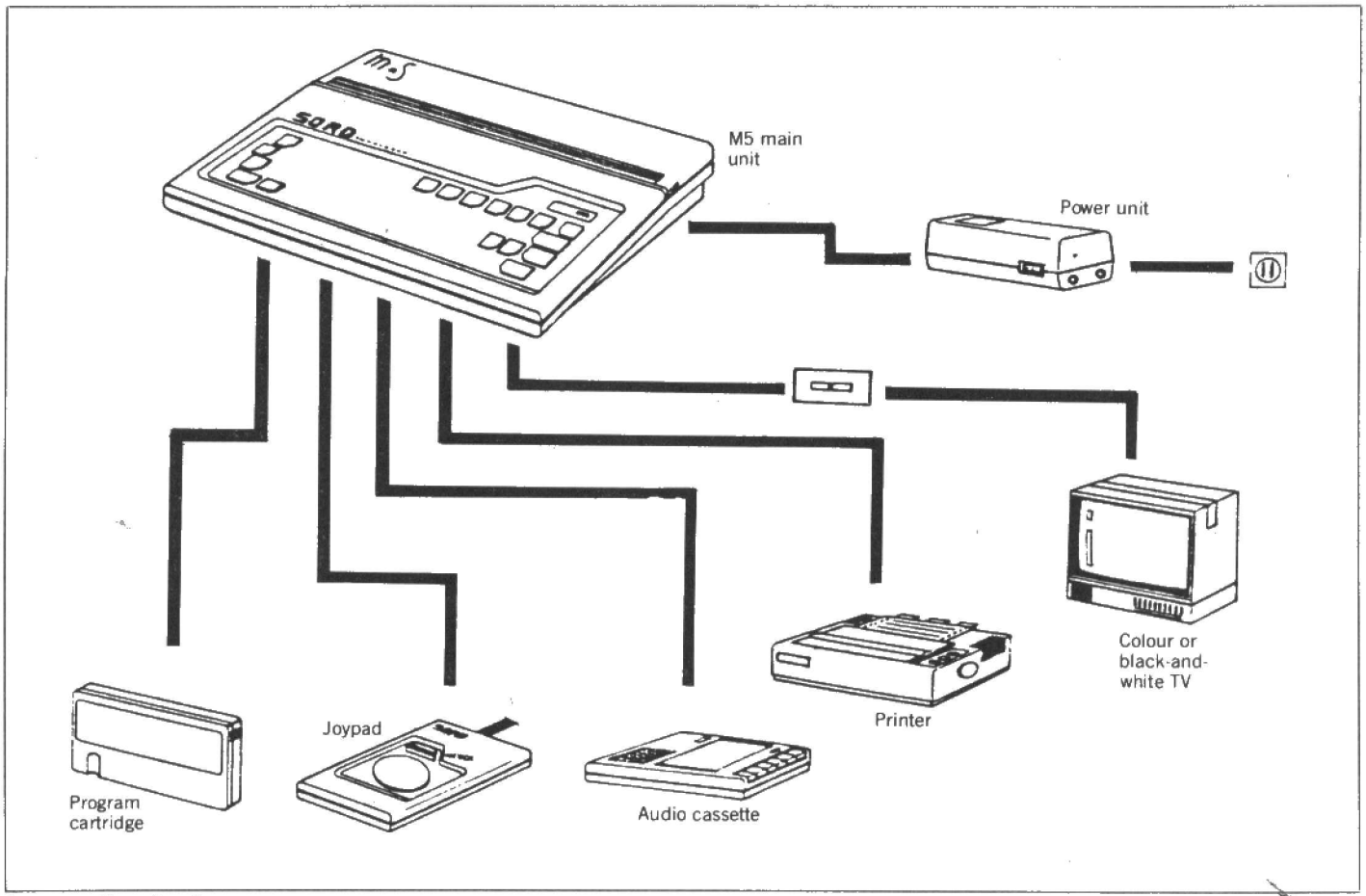
Along the back of the computer are two sockets for joysticks, a socket for a cassette recorder, an input socket for the power unit, a socket for connection to a standard UK PAL UHF TV set, and separate sockets for sound for connection to your hi-fi and composite video for connection to a monitor. In addition there is an 8-bit parallel output socket for a electronics type printer or disk drive.

But one of the most exciting features of this computer is found by flipping open the lid along the top rear of the unit. Here is unveiled the socket into which cartridge programs can be plugged in. However, unlike most such sockets, this one has 56 internal lines connected to it giving access to just about every function in the computer. This means that just about everything you can think of can be added on to the computer, ranging from a Prestel interface to second processors or use as an intelligent terminal on a time sharing computer.

Inside the M5

Inside the computer we find a Z80A processor running at around 3.58 MHz and 8K of ROM in which are the monitor program and the standard character sets. Only 4K of RAM is supplied with the machine, but this should not be compared directly with the amount of RAM supplied in other machines as we shall see.

The reason is the amazing graphics capability of this machine. It has a separate processor to control the video display and this has its own completely separate RAM (VRAM) and a massive 16K of it at that. This VRAM is not part of the memory that can be directly addressed by the Z80 and therefore whether you are using hi-res or lo-res graphics the amount of RAM available to the main processor is the same, unlike any other home computer we know of.



System configuration diagram.

Video Processor

The video processor is a very powerful chip, the TMS9918A which has 16-bit internal architecture, and, whilst even the Commodore 64 has only 8 sprites, this chip can generate no less than 32 at one time. At the same time a backdrop screen can be used and a further multicolour screen on which text or graphics may be displayed can be generated.

A sprite is a graphic symbol created by the program designer and is drawn on an 8 x 8 or 16 x 16 matrix. Sprites can be made bigger by combining them. Up to 32 sprites can be displayed at any one time and several of them may be moving at any one time.

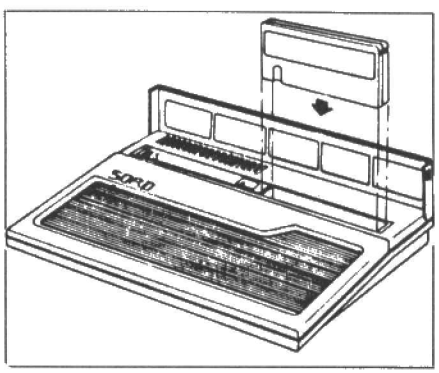
The sprite screens are numbered 0 to 31 and move in front of and behind one another depending on their priority. For example a missile drawn on screen 6 will disappear behind clouds on screen 5, but will move in front of clouds drawn on screen 7. An image larger than the screen can be created by using several screens and colours. The program could control this composite as one image.

Any image can be made to move automatically simply by specifying the start and end positions and the length of time during which this process will occur. The monitor is flagged whenever images on different screens collide and this can be detected by the program.

Behind the 32 sprite screens is a background plane which can be used in one of four modes. In Graphic 1 mode the screen has 32 x 24 positions where 8 x 8 characters can be specified. 256 different patterns are possible using 32 colours and in this mode characters can also be displayed. In multi-colour mode there are 64 x 48 positions where 4 x 4 characters can be displayed in 16 colours.

Text Mode

In text mode, 960 characters can be displayed in 24 rows of 40 columns. Each character is 6 x 8 dots, but only a single colour may be used and, in this mode, sprites cannot be used. In Graphics 2 mode you have complete control of every individual pixel and there are 256 x 192 (49,152) of them.

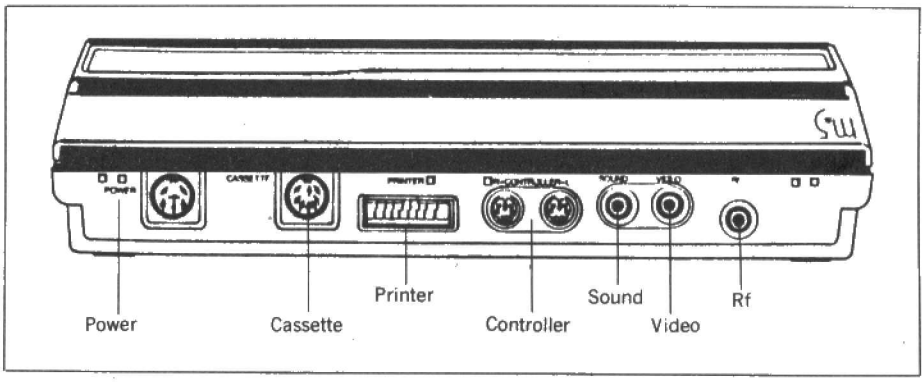


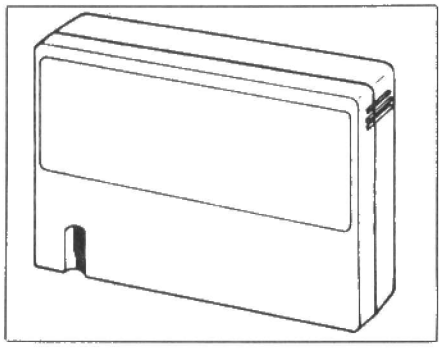
This background plane might be used for example to show a river or mountain as a background to a cartoon since the sprites can be used to create complete animated pictures, just as in a cartoon.

In addition, behind this plane is a backdrop plane. In this plane only one colour can be used in the example above, this plane would be blue and would look like the sky behind the river and mountain. Thus a whole image is made up of a combination of the 32 sprites, the background plane and the backdrop plane.

A Complete Cartoon

In a typical example the leaves of a tree are drawn in green on sprite screen 0 and the trunk of the tree is brown on screen 1. A car is drawn on screens 2 to 5; the tyres in black on screens 2 and 5 and the body of the car in two parts in blue on screens 3 and 4. Clouds are drawn on screens 6, 7 and 8. On the background plane is drawn grass in green, a grey road and mountains in brown. Now the car can be made to move smoothly along the road and





Program cartridge.

pass behind the tree, whilst the clouds in the sky move across, passing in front of and behind each other, just like a real animated cartoon.

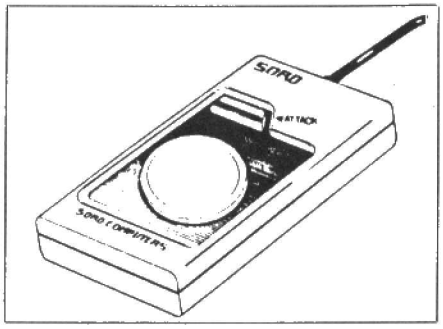
And the most exciting thing is the ease with which it can all be done. Everything described above can be executed from the special Graphics BASIC once you've got the hang of the machine. The excellent documentation allows even a novice programmer to achieve this kind of animation. You could even create your own complete cartoon stories!

Creating Sounds

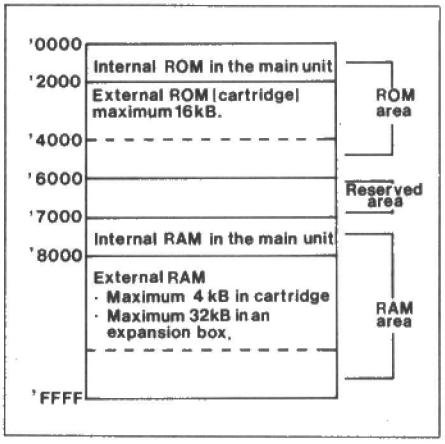
Of course no cartoon would be complete without a musical backing and the M5 has a very comprehensive sound source. The Texas Instruments 76489 is the IC we used in our Sound Generator for the ZX81 published in issue 5 of this magazine. The chip contains 3 tone generators with a five octave range each and a noise generator with three pitch levels. Envelope control of all four generators is available, which means that this computer contains a mini-synthesiser.

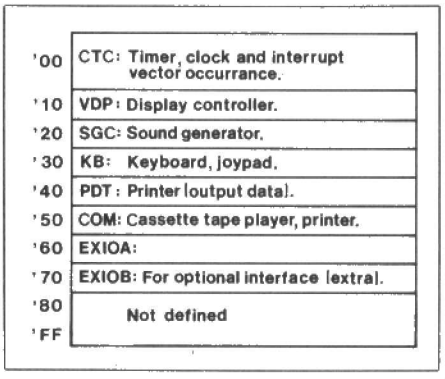
Three note chords can be generated and individual notes can be made to sound like particular instruments, violin, piano, etc., by controlling the envelope. This kind of control of the noise channel permits all kinds of sound effects, e.g. gunshots, explosions, car engines etc. In fact the sound generation possibilities with the M5 are very comprehensive indeed.

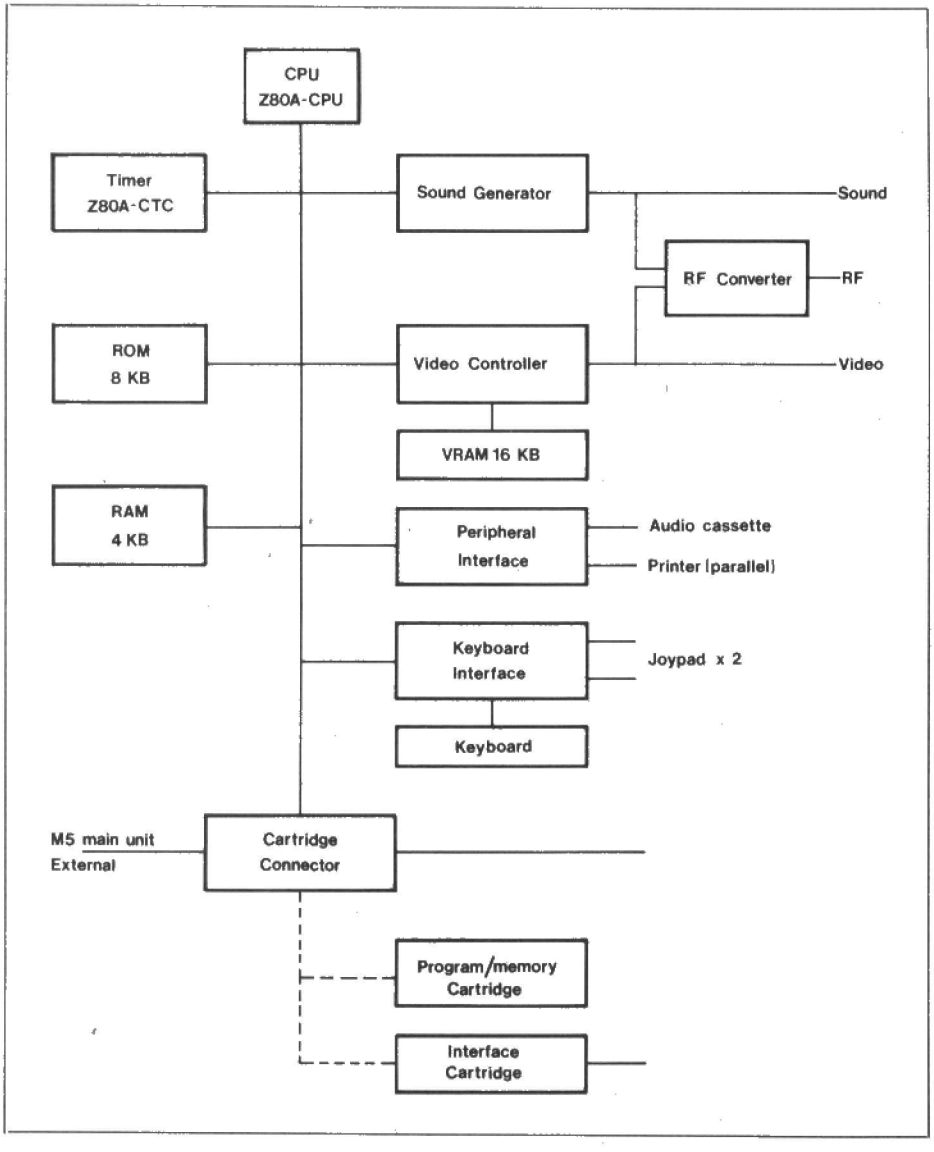
The sound output is to both the TV speaker and to a separate output for connection to a hi-fi setup. The documentation we had (not the ones to be supplies with the unit unfortunately) hinted at the possibility of



obtaining a voltage on this output instead of sound that could be used like a D/A converter to control robots.




'00 CTC: Timer, clock and interrupt vector occurrance.
'10 VDP: Display controller.
'20 SGC: Sound generator.
'30 KB: Keyboard, joypad.
'40 PDT: Printer (output data).
'50 COM: Cassette tape player, printer.
'60 EXIOA:
'70 EXIOB: For optional interface (extra).
'80 Not defined
'FF



Monitor Functions

The monitor program is contained in the first 8K of memory in ROM. Programs can make calls to the monitor or to the 768 bytes of RAM used by the monitor and I/O. The monitor controls a real-time clock which can be used as an event timer. Programs can have full use of this clock for incrementing, decrementing and controlling what happens at given times. In addition a program itself can be activated at a specified time. This timer is accurate to about 3 seconds an hour.

Other monitor functions include control of the video processor sprites and a collision register. It controls the graphic display at 256 x 192 points, and also supports several keyboard modes, including direct function calls to BASIC, for 26 of the most commonly used functions. The keyboard is scanned under control of the monitor, as are the joystick ports, though these two functions are independent.

The monitor controls the parallel output port to which a printer may be attached. Alternatively the output could be used as an 8-bit parallel switch, possibly in conjunction with the real-time clock for process control.

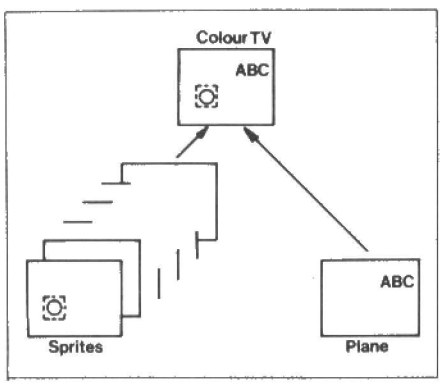
Graphics Capabilities

As always though, it is the graphics capability that is exceptional in this machine. By using the monitor and its registers, a view port can be set up on the screen. Here the TV screen acts like a window on a large scene and can be scrolled across the screen in any direction. It is also possible to control the right and left halves of the screen separately. In addition to all this the various modes: text, graphic, multi-colour can be called and mixed during a single screen and then the whole image displayed one screen at a time allowing jitter-free animation and games whose graphics really are on a par with the arcade machines.

The monitor also controls read from and write to the cassette tape. Any audio cassette recorder can be used with the M5 and the cable supplied plugs into the back of the computer. The three plugs on the other end of the cable connect to the earphone, microphone and remote sockets on the cassette recorder. Data transfer to the cassette recorder proceeds at an exceptionally fast rate. Speeds up to 3200 Baud are possible and the starting and stopping of the tape is under the computer's control.

Controllers

Two joysticks, or rather I should say joypads, can be connected to the M5. As with most computers these have to be purchased separately. Joypads, the manufacturers claim, are much easier to use than joysticks since they are less tiring in use and the smaller movements involved make them quicker. They are like a large round button on a flat box. Simply touching the edge of the button in the desired direction is all that is required. Movement can be controlled in eight directions as with a joystick. The fire button is just to the left above the movement button. Certainly they can be controlled with one hand unlike a joystick and are a lot less cumbersome. In addition a left-handed person will find them just as easy to use as a right-hander.



Software Availability

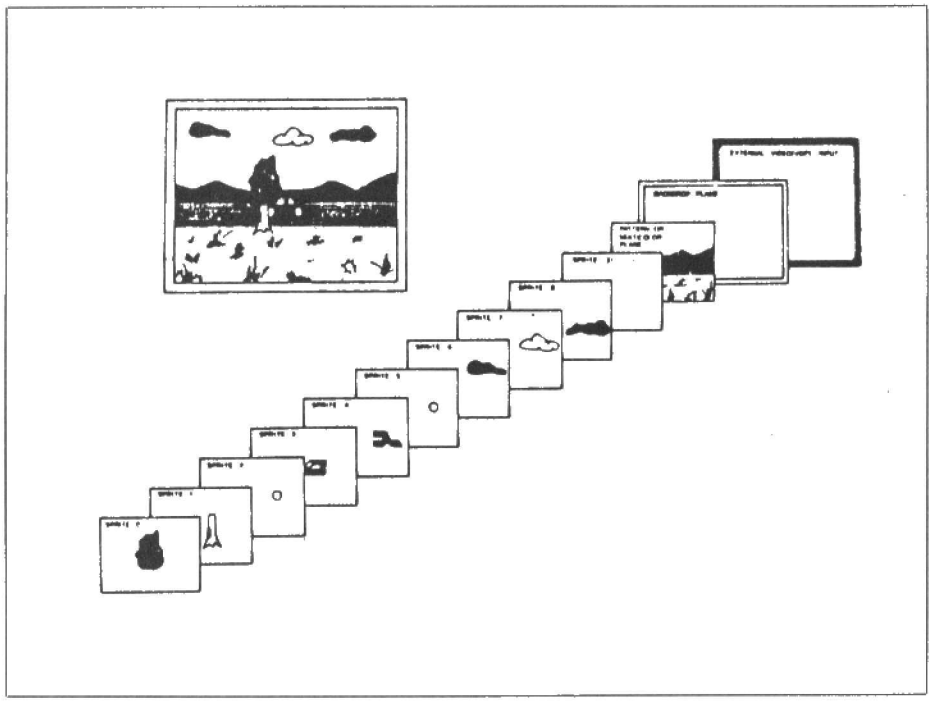
Another major advantage with this machine is the large amount of ready-made software that will be available. Fifty different programs will be available when the machine is launched and CGL are promising to have 200 different titles available before the end of 1983. Of the first fifty, thirty will be games and twenty will be educational, business and utility programs.

The games should be first class since Sord have signed an agreement with one of the leading manufacturers of arcade games to reproduce their titles under licence. A very powerful Visicalc-type program called FALC will be available too. Most of the programs will be in cartridge form, but some will be on cassette.

The cartridges which plug into the 56-way edge connector, are about the size of an audio cassette tape. They may contain up to 16K of ROM and many will also contain up to 4K of RAM. The M5 is supplied with the BASIC -I cartridge and one game cartridge.

Programming Languages

BASIC-I is an introductory integer BASIC which can be used to learn the fundamentals of programming the M5. In saying that, don't go away with the idea that it is a very limited BASIC. That is not the case. It contains most of the functions found in other BASIC's at this level, but it does not permit floating point maths, and it does not give complete access to the graphics or sound functions in the M5, although simple functions for games are included.



In BASIC-I a variable name can be 256 characters long, but only the first two characters are significant. When this cartridge is inserted, BASIC-I is automatically booted. It is contained in 8K of ROM and uses the 3.25K of free RAM as work space. This amount of RAM permits about 150 program instructions to be written in one program.

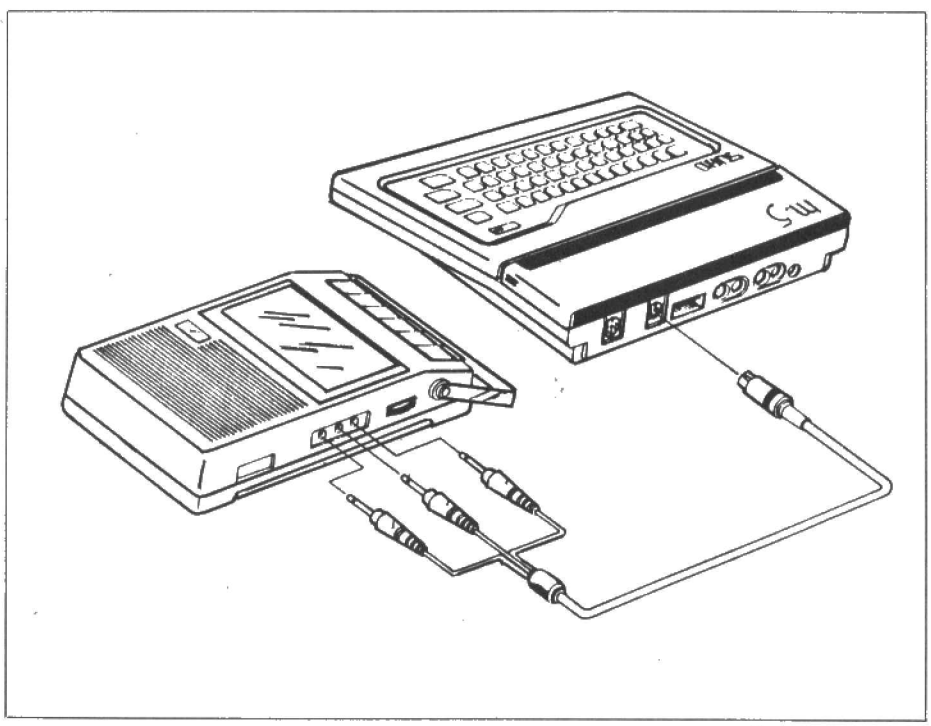
Two other BASIC's are available in cartridge. One is BASIC-F, a floating point BASIC that allows extended use of real numbers. Various numeric values and functions can be used for advanced technical processing. Data can be shown in graphs directly from BASIC-F. This BASIC is contained in 16K of ROM and contains an additional 4K of RAM.

The third BASIC is BASIC-G. With this BASIC, the sprites, background plane, backdrop plane and monitor can all be controlled directly. BASIC-G is ideal for creating games and animated sequences and will be easy to use once BASIC-I has been mastered.

BASIC-G has special functions for controlling the sprites, sound and joypads. Writing good games programs requires imagination and creativity and can help children develop these powers. BASIC-G brings good programming within easy reach of novice programmers.

Memory Expansion

CGL will be making available memory expansion boards at a very reasonable cost. A 32K expansion board will allow about 3000 program steps. It should be possible to expand the RAM so that all possible memory can be utilised. With BASIC-I a maximum of 35.25K is directly addressable, though a further 12K of memory addresses are avail-



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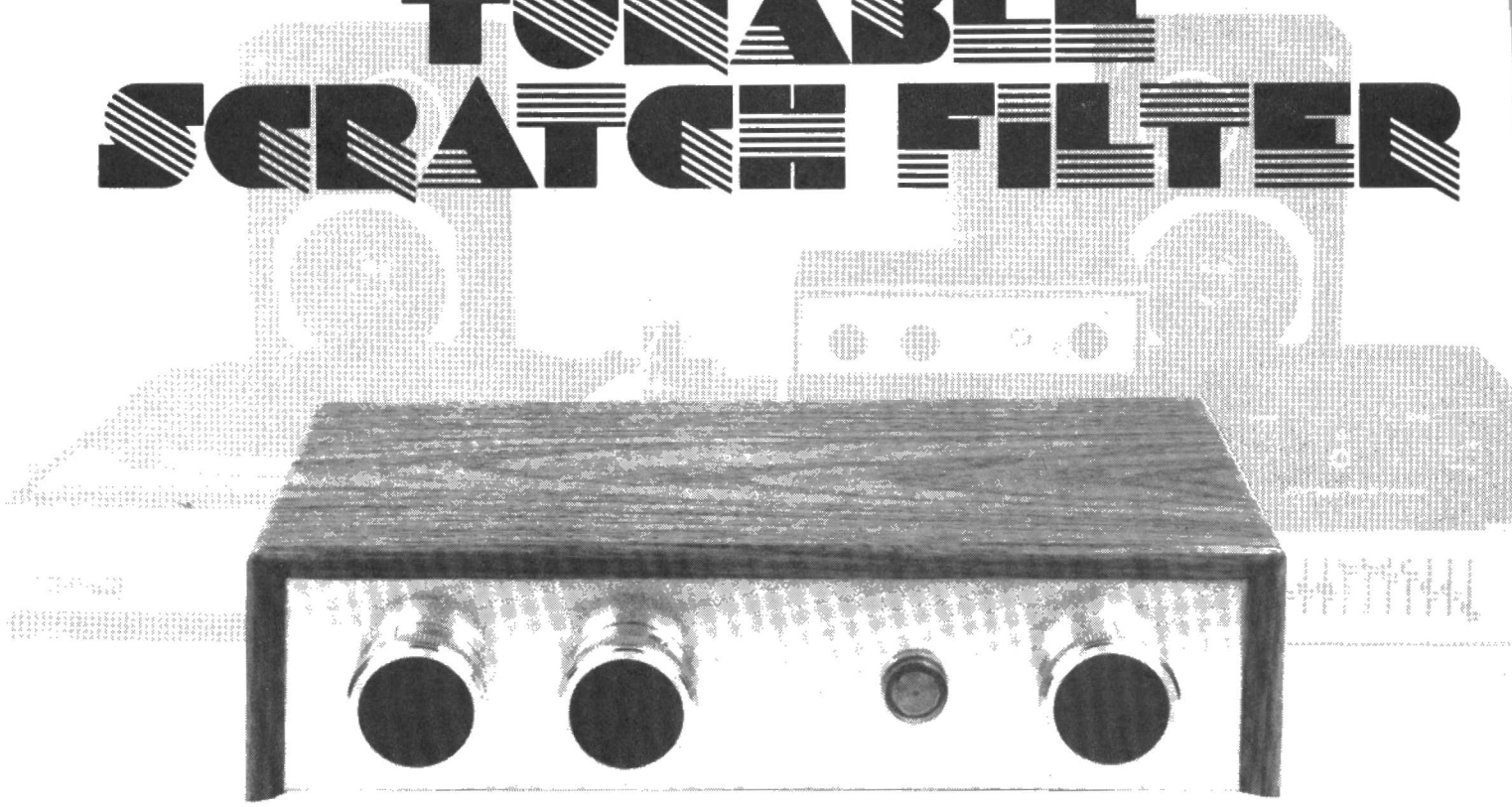
TUNABLE SCRATCH FILTER



by Robert Penfold

Worn or dusty records produce a continuous "crackle" of background noise in use, and as this noise is largely at high frequencies it tends to stand out from the wanted signal and is consequently very obtrusive. However, due to its mainly high frequency composition the "surface noise" as it is often called, can be virtually eliminated using a filter which attenuates high frequency signals. Obviously there is some loss of the wanted signal at high frequencies and not just the noise is removed, but this loss is far less noticeable than the reduction in noise and a very worthwhile improvement in the subjective quality is obtained.

An ordinary treble tone control can be used to provide suitable filtering, but results are less than optimum with the low attenuation rate of 6dB per octave provided by normal tone controls giving a relatively low level of noise reduction, plus a larger loss of the wanted signal than is really necessary. Much better results can be obtained using an active filter which has a flat response almost up to the cut-off frequency, with a high attenuation rate of about 12 to 24dB. per octave above this point.

Even with a filter of this type results may often be less than optimum since the cut-off frequency is not usually variable. The frequency chosen must then be a compromise which inevitably gives less than maximum noise reduction with some programme sources, and unnecessary attenuation of the main signal with other sources. Ideally it should be possible to adjust the cut-off frequency to optimize results, but using conventional C-R filters this would require a four gang potentiometer for a stereo 12dB. per octave filter, or an eight gang component for a stereo 24dB. per octave type! Also, mismatching between the gangs of the potentiometer could result in irregularities in the frequency responses of the filters, and a mismatch between the cut-off frequencies of the two channels.

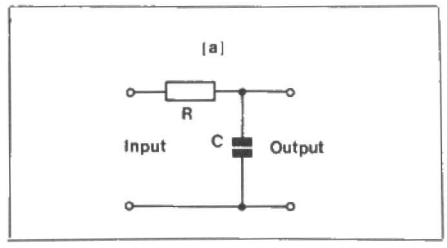


Figure 1a. Conventional R-C low pass filter.

Switched Capacitor Filter

These problems can be overcome using a relatively new type of filter called a "switched capacitor" filter. An ordinary C-R lowpass filter uses the arrangement shown in Figure 1(a), and

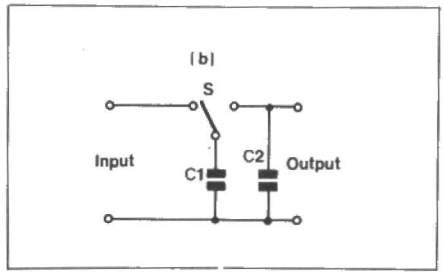


Figure 1b. Switched capacitor equivalent.

here the resistor restricts the rate at which the input signal can charge and discharge the capacitor. At low frequencies where only a low rate of charge and discharge are necessary to permit the output to follow the input signal accurately the filter has no significant effect, but at high frequencies the capacitor cannot charge and discharge with sufficient rapidity to keep up with changes in the input voltage. Thus the signal is attenuated and the lowpass filter action is provided.

A switched capacitor filter works in a similar manner, but the rate at which the filter capacitor can be charged and discharged by the input signal is controlled by a switch and a low value capacitor rather than by a resistor. Figure 1(b) shows the basic arrangement used.

C1 is first connected by switch S to the input and C1 is instantly charged to the input potential. C1 is then connected by S to C2, and C1 discharges into C2 but only partially charges it towards the input potential since C1 is much lower in value than C2. This process continues with C1 repeatedly charging to the input potential and then transferring its charge to C2. If the switching action is very rapid C2 quickly takes up a charge potential practically equal to the input voltage due to the numerous burst of current it receives from C1, and provided the input potential only changes slowly S and C1 will be able to maintain the charge on C2 at almost the input potential. At high frequencies, as was the case with the C-R filter, the transfer of current from the input to the filter capacitor is inadequate and the amplitude of the output signal is much

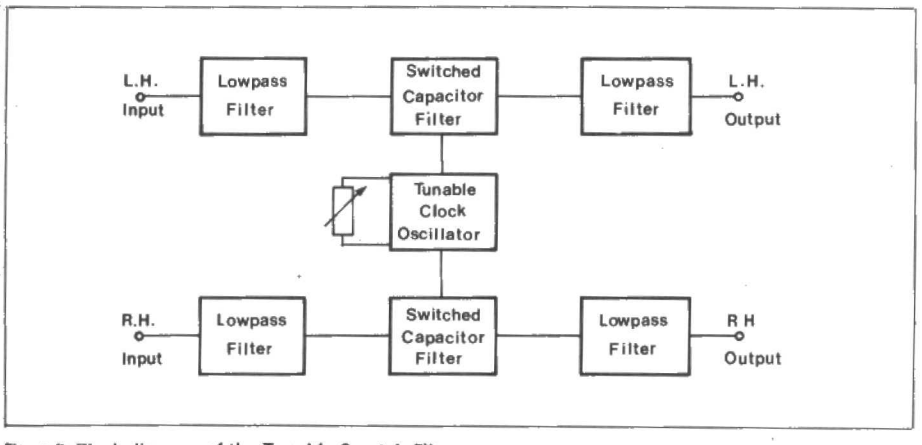
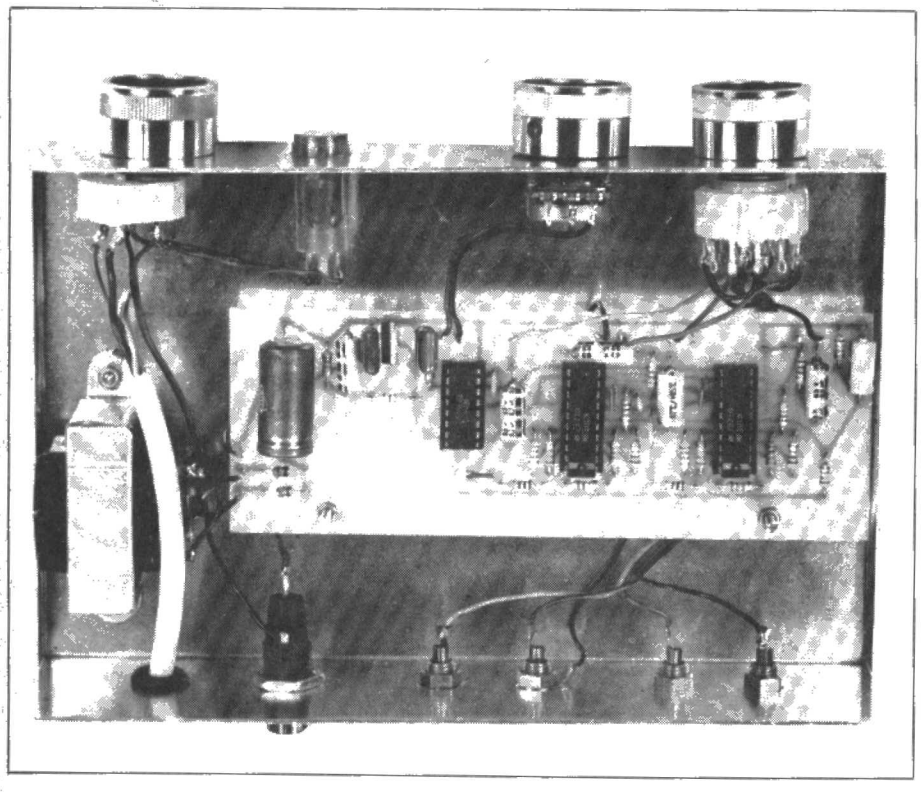


Figure 2. Block diagram of the Tunable Scratch Filter.



Internal view of the scratch filter.

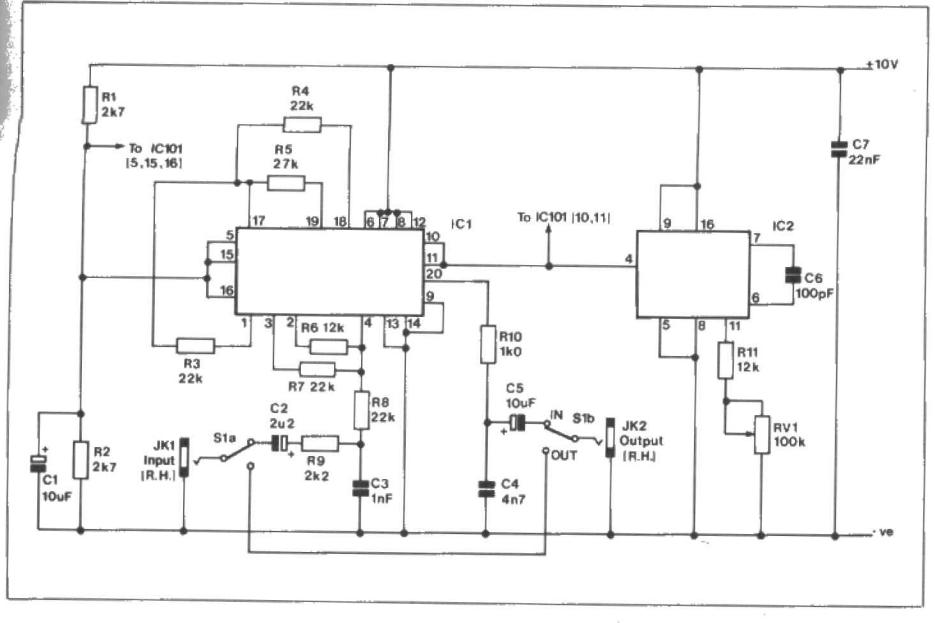


Figure 3. Circuit diagram of the Tunable Scratch Filter.

lower than that of the input signal.

The effective resistance provided by S and C1 depends on the value of C1 and on the switching frequency of S. In a practical circuit S would be formed by f.e.t.s. which would be on the same chip as C1 and C2 (with the latter normally being replaced by an integrator). It would, of course, be possible to produce conventional passive or active filters on a single chip, but the high resistor values that would be needed would make a device very expensive, and the cut-off frequency of the filter would be preset. Using a switched capacitor filter the effective resistance of S and C1 (and therefore the cut-off frequency of the filter) can be controlled by the clock frequency used to control S. Furthermore, the filters can be constructed with a high degree of precision so that a number of filters controlled by a common clock oscillator will have cut-off frequencies matched to typically within about 1%.

Block Diagram

The switched capacitor filted used in this project is the National Semiconductors MF10CN, and this has an input operational amplifier followed by a form of mixer circuit and two switched capacitor filters in series. This enables the device to be used in various operating modes so that highpass, notch, and bandpass functions can be obtained in addition to straight forward lowpass filtering, although in this application it is obviously used in a lowpass mode. The MF10CN actually contains two filters of the type described above, and these can either be used as separate second order filters, or connected in series to provide a fourth order (24dB. per octave) filter.

Figure 2 shows the block diagram of the "Tunable Scratch Filter", and the clock oscillator is at the heart of the unit. This has an operating frequency which is variable from about 150 to 750kHz, and the cut-off frequency of the MF10CN is one fiftieth of the clock frequency. This gives the filter a cut-off frequency which is continuously adjustable from about 3kHz to 15kHz. The clock signal is used to control two MF10CN switched capacitor filters having a 24dB. per octave attenuation rate, one device being used in each stereo channel. The two channels have responses that are accurately matched and they are tuned by a single gang potentiometer.

A simple lowpass filter is used at the input of each channel, and this is done merely to prevent stray coupling of radio frequency signals into the switched capacitor filters where heterodynes could be produced by an interaction with the clock signal. A simple lowpass filter is also used at the output of each channel to reduce breakthrough of the clock signal. The clock signal only breaks through at about 10mV. at the output of an MF10CN, but the output filter reduces this to less than 1mV. and makes quite sure that this signal cannot

cause any problems with the equipment that is fed from the output of the unit.

The Circuit

The circuit diagram of the scratch filter is shown in Figure 3. The clock oscillator uses IC2 which is a CMOS 4046BE phase locked loop, but it is employed here as a simple oscillator which has its operating frequency set by timing components C6, R11, and RV1. The latter is the tuning control of course. The 4046 is ideal for this application since its output levels are compatible with the MF10CN, it will operate from the same 10 volt supply as the MF10CN, and it will operate reliably at the quite high maximum frequency needed here.

IC1 is the filter device for the right hand channel, and this has pins 5, 15, and 16 biased to half the supply voltage by R1, R2, and C1. Pins 5 and 15 are unused inputs of the device, but they must be biased correctly or the circuit will not function properly. Pin 15 connects to the non-inverting input of the operational amplifier used at the input of each section of the device, and these amplifiers are used in the standard inverting mode. R8 and R7 set the input impedance and voltage gain of the amplifier at the input of the first stage at 22k and unity respectively. R3 and R4 perform the same function in the second section of IC1, and R3 is direct coupled to the output of the first filter section. R5 and R6 control the Qs of the filter sections, and these could be given a value of 22k to set both filters at a Q value of one. However, better results are obtained by giving the first filter section a lower value and a lower Q, and the second section a higher value and Q. This gives the first section a response that gives a rather gradual introduction of the attenuation, while the second section has a peak in the response followed by an abrupt introduction of the full attenuation rate. The combination of the two responses produces the excellent overall response shown in Figure 4. This is with RV1 set for a cut-off frequency of 5kHz, but the shape of the response remains unaltered at other cut-off frequencies.

R9 and C3 are the input lowpass filter, and the output lowpass filtering is provided by R10 and C4. C2 and C5 are D.C. blocking capacitors. Pins 7, 8, 13, and 14 of IC1 are merely supply pins, and there are control terminals which also connect to one or other of the supply rails. Pin 9 is the "level shift" terminal and is connected to the negative supply rail for use with a single supply and a CMOS (or TTL) clock signal. Internal switches of the device are controlled by a voltage applied to pin 6, and for the mode of operation utilized here it must be taken to the positive supply. Pin 12 is also taken to the positive supply rail, and this gives a cut-off frequency at one fiftieth of the clock frequency. Taking pin 12 to half the supply voltage sets the cut-off

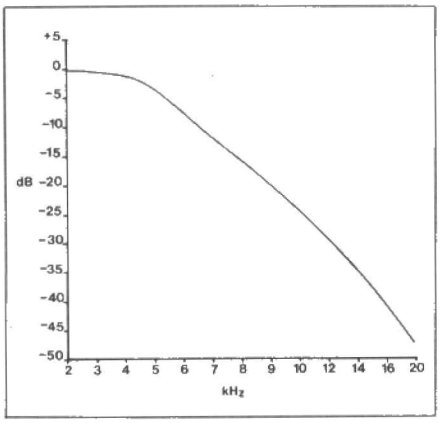


Figure 4. Frequency response of the filter when set for a 5kHz cut-off (-3dB).

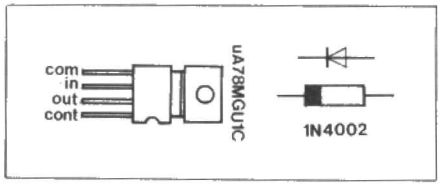
frequency at one hundredth of the clock frequency incidentally.

With some hi-fi systems it will be possible to bypass the unit using the tape monitor switch or some similar facility, but S1 can be used to bypass the unit if no other method is possible.

Note that Figure 3 only shows the filter for the right hand channel, but the circuit for the other channel is identical apart from the component identification numbers (which have one hundred added to the corresponding component number for the right hand channel). R1, R2, and C1 are used to bias the left hand channel as well as the right hand one, the clock oscillator is common to both channels, and a further two poles of S1 are used to bypass the right hand channel.

Mains Power Supply

The unit requires a stable, well smoothed 10 volt supply, and the supply current is only about 25mA. This is provided by the simple mains power supply circuit which is shown in Figure 5. IC3 is an adjustable voltage regulator which has the output potential set at nominally the required level by R12 and R13.



Construction

Details of the printed circuit board and wiring are given in Figure 6. Construction of the printed circuit board is quite straight forward, but use Veropins at points where connections to off-board component will be made. IC1, IC101, and IC2 are all CMOS devices, and these should therefore be fitted into sockets, and should not be fitted into place until the board is in other respects complete.

The general layout of the unit can be seen from the photographs, and for ease of construction and to avoid problems with stray pick-up of mains hum it is recommended that a radically different layout should not be used. Mains transformer T1 is mounted using ¼in 6BA bolts, and a soldertag fitted on one of these mounting bolts provides a chassis connection for the mains earth lead. The completed printed circuit board is mounted on the base panel of the case using 1in 6BA bolts with ½in spacers to keep the underside of the board well clear of the case. LP1 is a snap-fit into a 12mm diameter hole, and this must be the correct size if LP1 is to fit into place properly. The entrance hole for the mains lead is fitted with a small grommet which protects the cable.

Once everything has been fitted into the case the final wiring can be completed, and this is all quite easy, but be careful not to make any errors in the wiring to T1, S2, FS1, and the mains lead. Check this wiring very thoroughly when the unit has been completed and before switching it on.

Using The Unit

Ideally the unit should be wired between the preamplifier and power amplifier stages of the hi-fi amplifier, and many amplifiers have a tape monitor facility or something of this nature that will enable the filter to be used in this way. An alternative way of using the unit is to feed the input from the record deck via a suitable pre-amplifier, and then feed the output of the filter to a high level input (tape, tuner, aux., etc.) of the amplifier. The audio noise output of the filter is about 300uV, and this gives a signal to noise ratio of more than 60dB. provided the

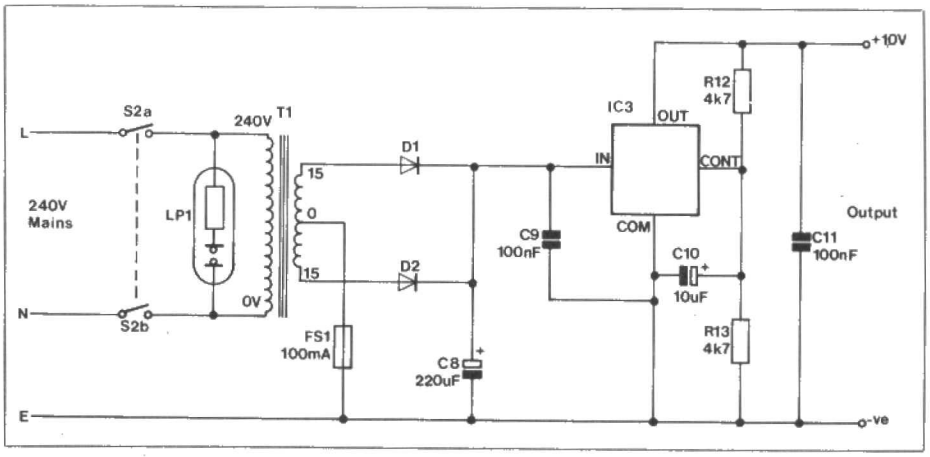


Figure 5. Circuit diagram of the mains power supply.

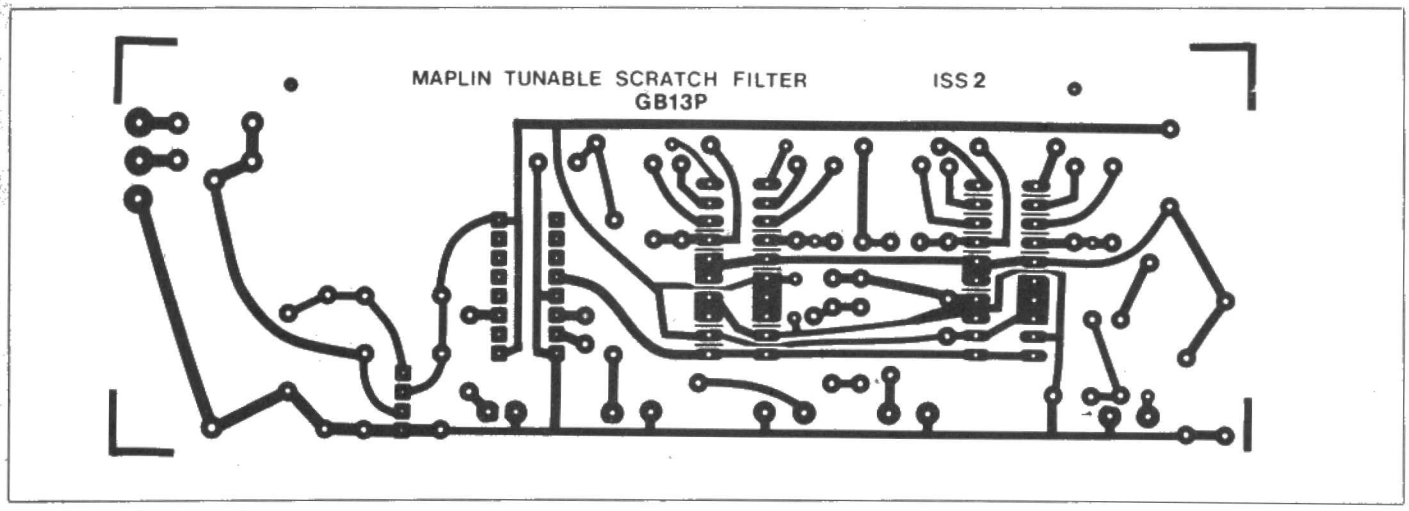


Figure 6. Legend and artwork.

unit is used to process a reasonably high level signal. It will not work properly if fed direct from the output of a pick-up since it would be handling a very low level signal and would give a very poor signal to noise ratio.

The filter can be used to good effect with tuners and cassette decks to combat noisy F.M. reception, or to reduce tape "hiss" when playing a non-Dolbyised cassette. When used in this way the unit can simply be connected between the tuner or cassette deck and the amplifier, with S1 being used to bypass the filter when it is not needed.

The best setting for RV1 is found by trial and error, and it should be set for the highest cut-off frequency that gives good noise reduction. In most cases there is a well defined setting at which the offending noise becomes practically eliminated as RV1 is gradually backed-off from its highest setting. It should be borne in mind that a filter of this type is not suitable for combatting the large noise spikes produced by badly scratched records as these produce strong signals at quite low frequencies, and not just at high frequencies.

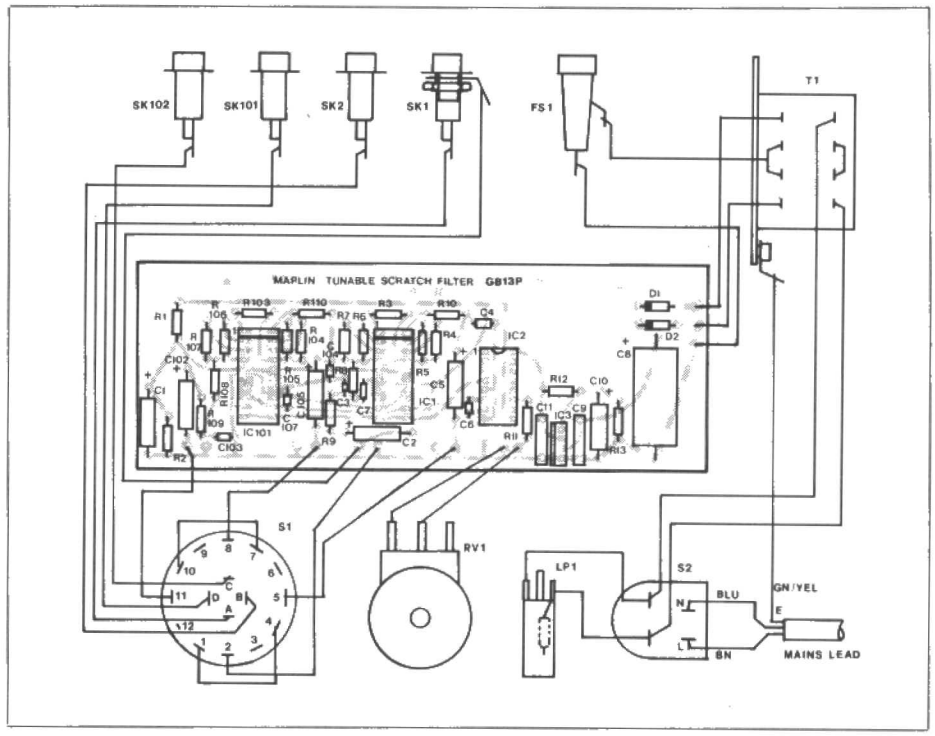


Figure 7. Wiring diagram.

PARTS LIST FOR TUNABLE SCRATCH FILTER

Resistors — All 0.4W 1% Metal Film			
R1,2	2k7	2 off	(M2K7)
R3,4,7,8,103, 104,107,108	22k	8 off	(M22K)
R5,105	27k	2 off	(M27K)
R6,11,106	12k	3 off	(M12K)
R9,109	2k2	2 off	(M2K2)
R10,110	1k	2 off	(M1K)
R12,13	4k7	2 off	(M4K7)
RV1	100k lin pot		(FW05F)
Capacitors			
C1,5,10,105	10uF 25V axial electrolytic	4 off	(FB22Y)
C2,102	2u2 63V axial electrolytic	2 off	(FB15R)
C3,103	1nF ceramic	2 off	(WX68Y)
C4,104	4n7F ceramic	2 off	(WX76H)
C6	100pF ceramic		(WX56L)
C7,107	22nF ceramic		(WX78K)
C8	220uF 25V axial electrolytic		(FB62S)
C9,11	100nF polyester	2 off	(BX76H)
Semiconductors			
D1,2	1N4002	2 off	(QL74R)
IC1,101	MF10CN	2 off	(QY35Q)
IC2	4046BE		(QW32K)
IC3	uA78MGU1C		(WQ78K)

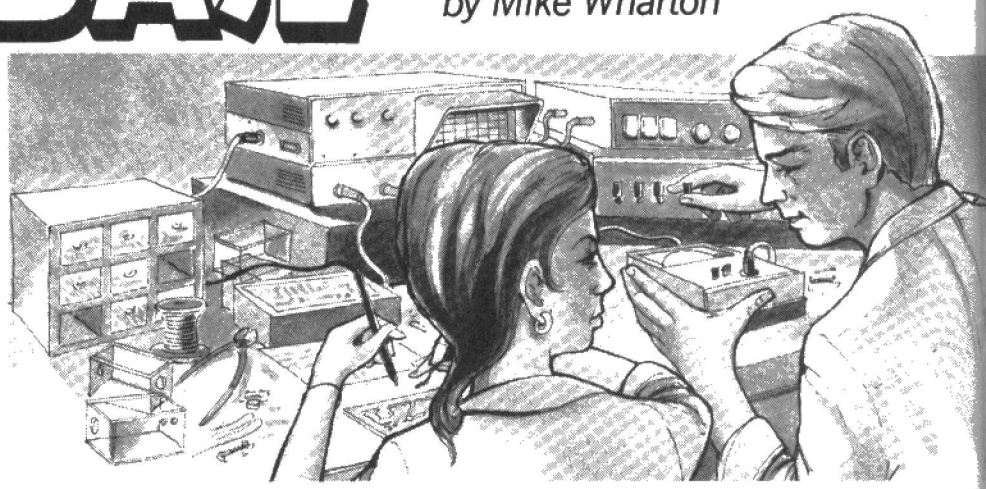
Miscellaneous			
S1	Rotary 4 pole 3 way		(FF76H)
S2	Rotary mains switch		(FH57M)
SK1,101,2,102	Threaded phono sockets	4 off	(YW06G)
T1	Mains transformer 15V 6VA		(WB15R)
FS1	100mA quickblow fuse 20mm		(WR00A)
LP1	Mains panel neon		(RX82D)
	Printed circuit board		(GB13P)
	Case Type TP3		(LH45Y)
	Control knobs	3 off	(HB34M)
	20mm Safuseholder		(RX96E)
	20 pin DIL socket	2 off	(HQ77J)
	16 pin DIL socket		(BL19V)
	Grommet small		(FW59P)
	Cabinet feet		(FW19V)
	13A mains plug		(RW67X)
	Min mains cable	2m	(XR01B)
	Hook-up wire black		(BL00A)
	Veropins type 2145		(FL24B)
	Bolt ¼in 6BA	2 off	(BF05F)
	Bolt 1in 6BA	2 off	(BF07H)
	Nut 6BA	4 off	(BF18U)
	Tag 6BA		(BF29G)
	Spacer 6BA × ½in	2 off	(FW35Q)

A complete kit of parts excluding the case is available for this project. **Order As LK04E (Scratch Filter Kit) Price £24.90**

FIRST BASE

A Beginner's guide to Logic Design

by Mike Wharton



Introduction

This new series will explain to the novice some of the rudiments of Logic design using integrated circuits. Rather than simply being a theoretical approach, the series will look at practical designs which may be made up on Veroboard or a breadboard. Many of the circuits will use commonly available TTL devices, and this first article outlines the design of a simple 5 volt supply for use with the experiments during the series.

Power Supply

Before you can venture forth on making any project in electronics you need a supply of electrons, you need lots of them, and they must be kept moving! Common sources are cells and batteries, like the zinc-carbon and alkaline-manganese ones, but these are becoming more and more expensive, have a fairly low capacity, and are definitely non-returnable when empty! Many schools possess very rugged low-voltage power supply units (psu), which allow the mains supply to be used with safety. These units are able to deliver several amperes at a voltage which is variable between zero and about 17 volts. Such psu's are fine for lighting bulbs, driving motors and copper-plating Sir's door keys during Chemistry lessons, but sensitive electronic circuits like to be supplied with more refined electrons. This article describes how regulated power supply units operate and how to construct one suitable for the projects in this series.

Smoothing, or, when is DC not DC?

You may know that the 'mains' supply in this country is described as Alternating Current (AC); this means that the current, and the voltage, is constantly changing. This is not on an irregular basis, but smoothly and regularly 50 times every second. If you think that sounds fast it is really quite slow compared to radio frequency (RF) voltages which may alternate at anything up to many millions of times per second. So, we have this alternating supply, and a graph of the mains voltage against time would look like Fig. 1. Since the supply voltage alternates 50 times each second, its frequency is 50 hertz, hertz being the units used for describing frequency named after Heinrich Hertz, but that's another story. The voltage of 240 volts marked on Fig. 1 is the value used to describe the mains voltage, i.e. 240 volts AC. Some of you will have recognised the curve shown in Fig. 1 as a sinewave, and that the value of 240V is the Root Mean Square value, or RMS for short. If you didn't know that don't worry, use it to impress your friends; it's actually the value of Direct Current (DC) needed to produce the same heating effect in a resistance. You may well be wondering what all this has to do with our little DC power supply unit, and it's this: AC is great for getting the electrons from the Power Station into our homes, because it means that transformers can be used to step up the voltage for transmission, and then back down again. The heart of most psu's is a transformer which reduces the lethal 240V mains to a safer 20V or so. However, AC is not much good for powering circuits designed to

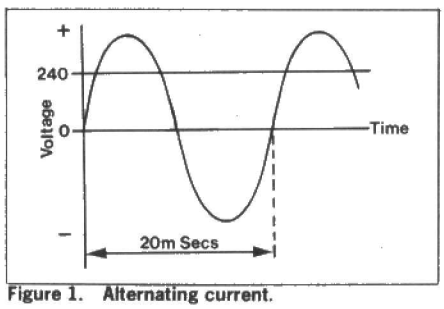


Figure 1. Alternating current.

operate on DC, since the polarity of the supply changes every half cycle, and polarity sensitive components like transistors would be zapped on the first negative wave. The simplest way to convert AC into a sort of DC is to block these negative half waves with a diode. A simple circuit, shown in Fig. 2, will block the negative half waves, and the slightly more complicated ones in Figs. 3 and 4 will produce the waveforms shown alongside. However, you couldn't really call the outputs from any of these circuits DC, at least it's nothing like the steady voltage produced by a battery. The answer is to connect a capacitor, as shown in Fig. 5. This is called a reservoir capacitor and it serves to store up electrons and let them out in a more even stream, rather like a full-size water reservoir. The resistor marked as the Load in Fig. 5 represents the circuit being supplied with current by the psu; it may be just a resistor, but it's more likely to be a transistor radio, or even a whole computer, the effect is just the same. The reservoir capacitor is charged up by the current from the diode rectifiers, then, as this falls back to zero, the capacitor is able to maintain a flow of current through the Load until it is charged again on the next half-cycle. The larger the Load, that is the smaller the resistance, so the more rapidly it will empty the reservoir, and hence it needs to have a fairly high value of capacitance. For small loads, taking just a few milli-amps of current, then values around 1000uF to 4700uF will suffice, but where larger currents are involved, such as in a computer, values of 20,000uF to 33,000uF (20 to 33 milli-farads) are needed.

All this may seem sufficient to produce a fairly respectable output, but, as Fig. 6 shows, it is still far from perfect. The output from our evolving design contains what is called 'ripple' (unfortunately, not the raspberry type!). What is needed is some clever device which can compensate for the variations in the waveform, to let more current through when it falls and block it off when it rises. Although the ripple may not have a very large value, often less than half a volt, it will make its presence felt in many circuits in no uncertain manner.

Zener Diode to the Rescue!

Possibly the simplest way of producing a constant voltage from one which varies is to use a zener diode. The characteristics of this device are shown in Fig. 7. In the forward biased direction it behaves like most other

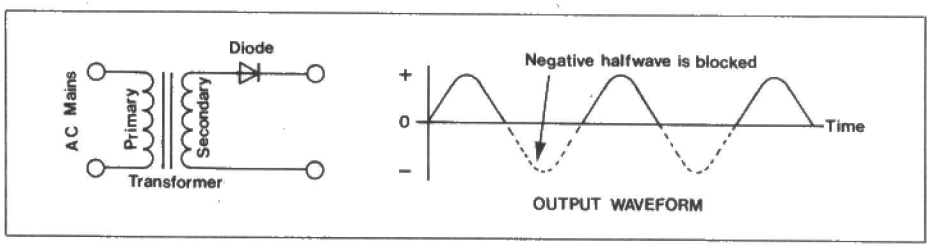


Figure 2. Simple diode rectifier circuit.

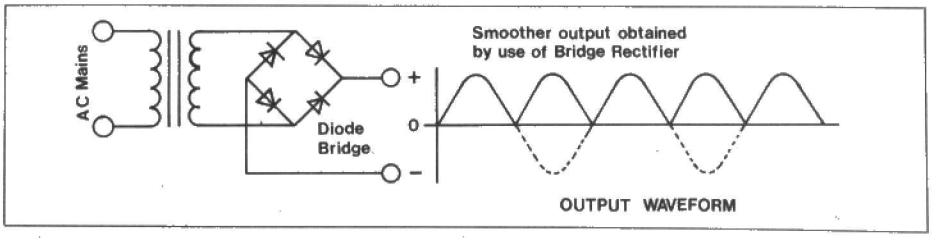


Figure 3. Bridge rectifier circuit.

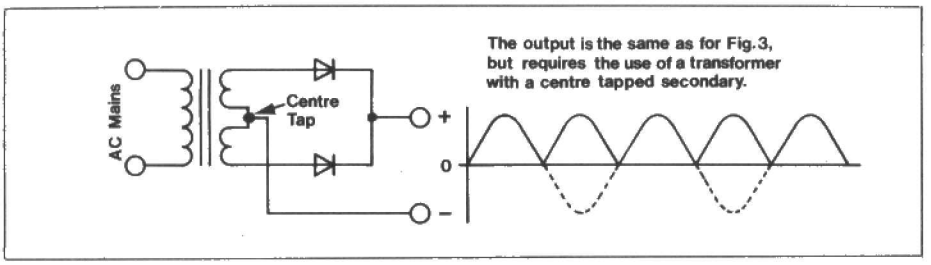

AC Mains
Centre Tap
+
0
–
The output is the same as for Fig.3, but requires the use of a transformer with a centre tapped secondary.

Figure 4. Full wave rectifier circuit.

diodes, nothing remarkable in that; however, in the reverse direction, the current passed remains very small until a certain voltage is reached, the zener voltage, then whoosh. . . a very large current will pass. To use such a device a resistance is needed in series to limit the current to a safe value, so that the diode doesn't get too hot and burn out. The zener voltage can be arranged during manufacture to be any value, and a quick look at page 277 of the Maplin catalogue will show that they are made with certain preferred values, rather like resistors. A very simple design, using a zener diode connected to the rest of the components used so far, is given in Fig. 8. This will produce a 'regulated' output, but there is a snag (there had to be a snag, life is never that easy!). Such an arrangement is only able to supply a limited current, and probably much less than any power supply unit worth the name. Ohm's Law will tell you the maximum current you can draw before the output voltage falls below the zener voltage. Suppose we want a 5 volt supply to run our home computer, and so we would choose a 5V zener diode. Suppose also that having spent all the pocket money on the computer we can only afford a zener diode able to dissipate 400 milli-watts, about the cheapest available. This gives us a zener current of:—

$I = P/V$

therefore, $I = 0.4/5$ which gives a zener current of 80 milli-amps. If our un-regulated supply produces 9 volts DC, the value of the series resistor will then have to be:—

$R = V/I$

so, $R = (9-5)/0.08$ ohms

$= 4/0.08$ ohms

therefore, $R = 50$ ohms.

So, you may well be asking, where's the snag? So far we have not taken any current by an external load; if we attach a load resistance which will pass 50 milli-amps then this current will be diverted from the zener diode, so that the total current remains 80mA, and the voltage dropped by the resistor is still 4V. However, if we try to take more than 80mA there will be nothing left for the zener (sighs!) and the voltage dropped by the resistor will be more than 4V; zip goes our regulated supply of 5 volts, for these currents are only a small fraction of that required by even a modest computer. This type of circuit is only suitable for providing a constant voltage for critical parts of a design, such as oscillators, where it helps to maintain frequency stability, and only a small current is taken. One solution to our problem would be to use a zener diode with a larger power dissipation, but, I can hear you say, there must be a better way that doesn't turn all our expensive electrons into heat before they have a chance to do any useful work.

Head them off at the Pass!

The zener diode is very good at providing a constant reference voltage, but what it really needs is more muscle. This is usually arranged by using the zener to control a power transistor, such as the 2N3055, in an arrangement known as a Series Pass circuit shown in Fig. 9. Here, the original zener diode circuit is used to provide base current for the series pass transistor, which then amplifies the current available to the external load. This type of circuit is able to provide a fairly constant voltage output under varying load conditions. To go back for a moment to the example of the home computer, which may require several amperes, the transistor will drop the 4 volts, assuming the 9 volts remains the same, but pass a current which depends on the load resistance. The point to note is that although power dissipation in the zener is no longer a problem, you must take care that the limits of the power transistor are not exceeded, and this will normally be mounted on a heat sink if large currents are involved.

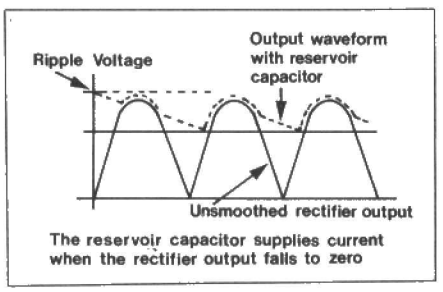

Ripple Voltage
Output waveform with reservoir capacitor
Unsmoothed rectifier output
The reservoir capacitor supplies current when the rectifier output falls to zero

Figure 6.

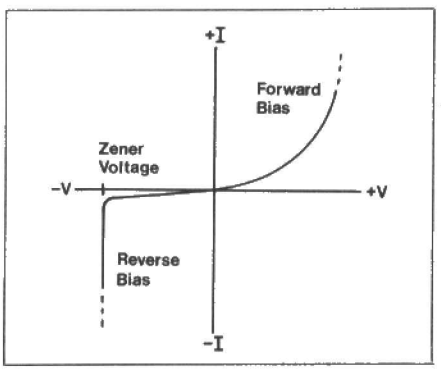


Figure 7. Zener diode characteristics.

A Practical Design

All of the above theory can be put together to produce the design shown in Fig. 10. There is nothing remarkable about the design, and many will recognise it from similar commercial designs. The capacitor connected across the zener is to ensure that the base current to the power transistor is as smooth as possible, since small variations here will be amplified and make matters worse rather than better. The appearance of a couple of extra transistors in the final design also requires some explanation. Transistor TR1 is the power transistor, which is supplied with base current from the zener diode via TR2; this arrangement permits a lower zener current to be used, and TR2 is needed to increase the base current to the power transistor. Transistor TR3 is included with R3 to provide some degree of short circuit protection. When the voltage developed across R3 due to the passage of load current increases beyond about 0.6 volts, TR3 will start to conduct and divert base current away from TR1 thus limiting the load current to around 2 amps. Finally, D5 is included to indicate that the unit is switched on.

Construction

The power supply unit may be constructed on Veroboard, remembering to mount the power transistor, TR1 on a suitable heat sink. A better alternative is to use a printed circuit board.

Also, it is worth bearing in mind that since mains voltages are present at the input side of the transformer, great care must be taken to ensure that it is impossible to touch any of the 'live' parts. For this reason it is a very good idea to mount the unit in a proper project box which can be earthed, otherwise you are in danger of defeating the whole object of the exercise, which is to remove the hazard of mains voltages! This should also be borne in mind if it is

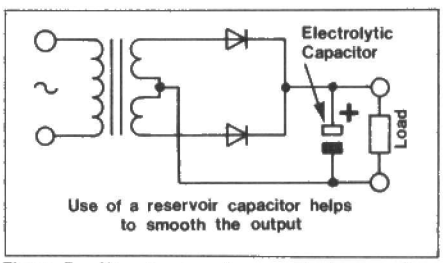


Figure 5. Use of reservoir capacitor to smoothe the output.

necessary to investigate any reasons why the unit does not function as intended; the golden rule here is make certain the mains is disconnected before probing with your fingers. A voltmeter applied to the output should indicate between 4.5 and 5.5 volts at worst, and should be close to the 5 volts required for TTL work if the unit has been put together correctly. If the voltmeter reading is outside these limits then switch off immediately and check your work; things to look out for are solder bridges across tracks on the circuit board, components incorrectly placed and the electrolytic capacitors the 'wrong way round'.

If the metal box specified is used, then the power transistor may be mounted on the rear of the case along with an insulating mica washer; again, remember to use wire of adequate size and rating for those connections which carry the high currents.

Having successfully completed the power supply unit you will then be in a position to commence the experiments on logic design without any fear of destroying the integrated circuits due to inappropriate supply voltages.

continued on page 25

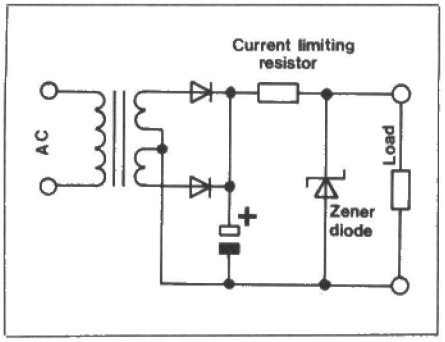
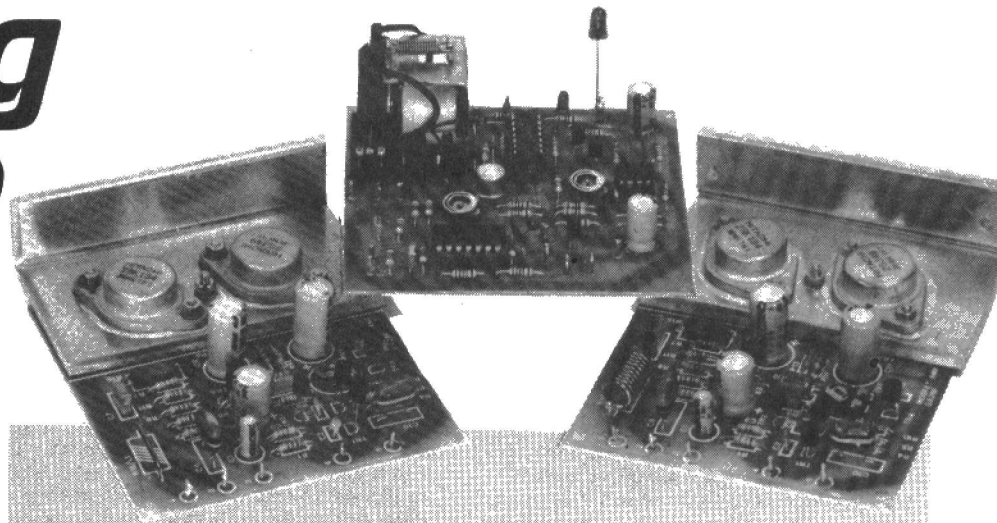


Figure 8. Use of a zener diode to provide a constant voltage output.

75W MOSFET Amp. Bridging Module

by Dave Goodman



- Increases power output to 400W
- 'Anti Thump' delay at switch on
- Loudspeaker protection
- Short circuit and offset protection

The Maplin MOSFET power amplifier has proved an extremely popular project, and many requests have been received for increased power output levels. Power Bridging is an effective way of achieving this, but of course loudspeakers capable of handling high power levels cost more, and therefore protection from any possible damage becomes even more necessary. This system senses voltage offsets from the amplifier, and will switch the speaker out of circuit, as well as producing the inverted signals required for bridging two amplifiers together.

Power Bridging

Power bridging is a system where the output of two power amplifiers can be combined to provide a larger total output into a common speaker load (see figure 1).

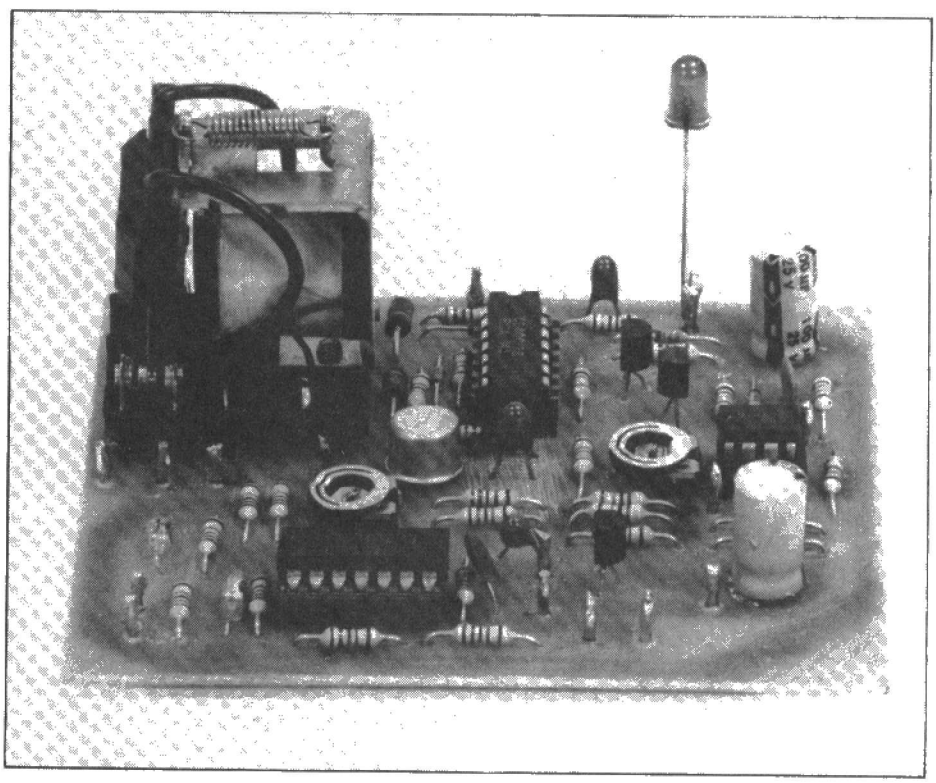
If we assume that signal A is exactly 180 degrees out-of-phase with signal B, and that amplitude V of A and B is the same, then the combined signal amplitude across the speaker load in figure 1 will be 2V.

It is usual to express amplifier power ratings as RMS or peak output levels, and for the purposes of standardisation I will refer to RMS power (that being the most commonly used) throughout this article.

The expression used for calculating power into a given load is $W(Av) = \frac{(V_{RMS})^2}{R}$, where W = RMS power and V = the RMS value of voltage measured across loudspeaker R.

Unfortunately the average power calculation does not consider true voltage and current RMS values, so calculations using this expression will be some 20% lower than the true RMS figures.

Now that we have an expression for power developed in a load for one amplifier, the two amplifiers shown in figure 1 will have the expression $W = \frac{(V_{RMS}\ (AMP1) - V_{RMS}\ (AMP2))^2}{R}$ because the load R is common to both amplifiers and W is the total power from both amplifiers.



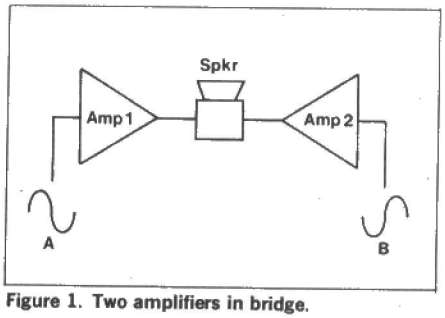


Figure 1. Two amplifiers in bridge.

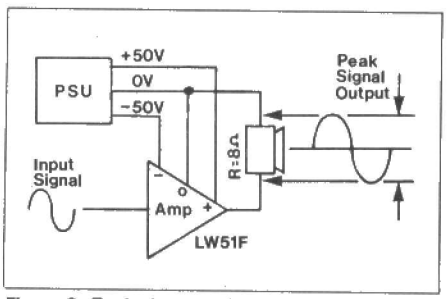


Figure 2. Typical connections to a single amplifier.

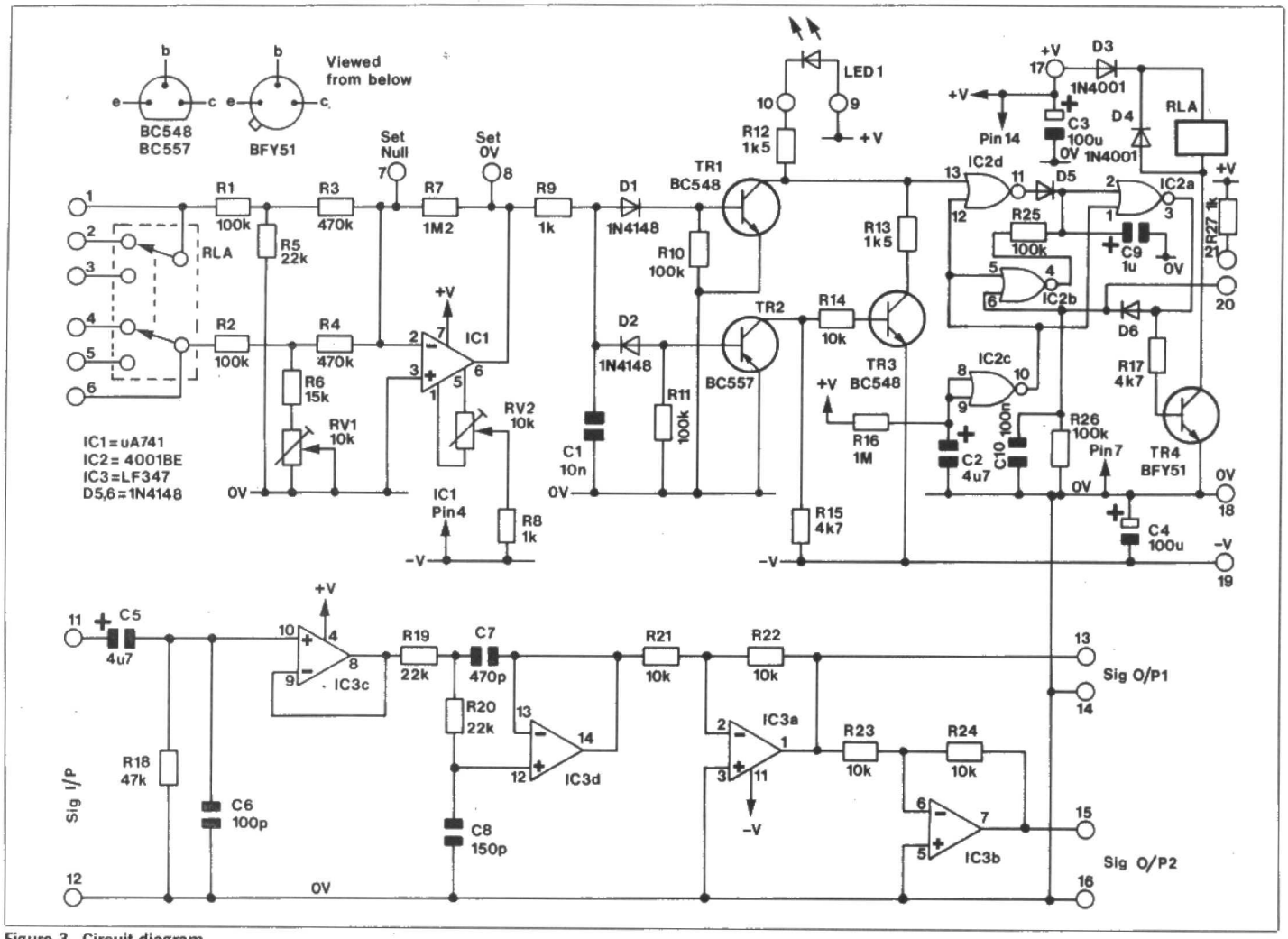


Figure 3. Circuit diagram.

To understand these formulae in real terms it is necessary to convert the peak voltage across the load into RMS volts which can be calculated from

$$V_{(RMS)} = \frac{V_{(PK)} \times 0.707}{2}$$

Given a power supply of +50V (or 100V DC) connected to a MOSFET power amplifier (LW51F) and an 8 ohm speaker as in figure 2, full drive at 1% distortion at 1kHz would develop 100V peak or $\frac{100}{2} \times 0.707 = 35.35$V RMS signal across R. Therefore the average RMS power would be $\frac{(35.35)^2}{2}$, or 156 Watts.

This magical figure works only in theory, and in fact losses due to heat, output stage inefficiency, and supply regulation would reduce this figure to a more realistic 100W RMS.

Connecting a second MOSFET amplifier as in figure 1, and referring to the expression $W = \frac{(V(AMP1) + V(AMP2))^2}{2}$ the RMS power output will be $W = \frac{(35.35 + 35.35)^2}{8} = 624$ Watts, or a realistic 400W.

All the above formulae show that bridging two amplifiers together doubles their combined power output, or quadruples a single amplifier output. Power supplies used for bridging must be capable of delivering 8 to 10 Amps at a well regulated 100 volts (+50V) if high

PARTS LIST FOR MOSFET BRIDGE

Resistors — All 0.4W 1% Metal Film unless specified

R1,2,10,11,25,26	100k	6 off	(M100K)
R3,4	470k	2 off	(M470K)
R5,19,20	22k	3 off	(M22K)
R6	15k		(M15K)
R7	1M2 (¼W 5%)		(B1M2)
R8,9,27	1k	3 off	(M1K)
R12,13	1k5	2 off	(M1K5)
R14,21,22,23,24	10k	5 off	(M10K)
R15,17	4k7	2 off	(M4K7)
R16	1M		(M1M)
R18	47k		(M47K)
RV1,2	10k Hor sub-min preset	2 off	(WR58N)

Capacitors

C1	10nF disc ceramic		(BX00A)
C2,5	4u7F 16V Tantalum	2 off	(WW64U)
C3,4	100uF 25V PC electrolytic	2 off	(FF11M)
C6	100pF ceramic		(WX56L)
C7	470pF polystyrene		(BX32K)
C8	150pF polystyrene		(BX29G)
C9	1uF 35V tantalum		(WW60Q)
C10	100nF disc ceramic		(BX03D)

Semiconductors

D1,2,5,6	1N4148	4 off	(QL80B)
D3,4	1N4001	2 off	(QL73Q)
TR1,3	BC548	2 off	(QB73Q)
TR2	BC557		(QQ16S)
TR4	BFY51		(QF28F)
IC1	uA741		(QL22Y)
IC2	4001BE		(QX01B)
IC3	LF347		(WQ29G)

Miscellaneous

RLA	Power relay 12V		(FX48C)
LED1	Red LED		(WL27E)
	14-pin DIL skt	2 off	(BL18U)
	8-pin DIL skt		(BL17T)
	Printed Circuit Board		(GA17T)
	Veropin 2141	1 Pkt	(FL21X)

A complete set of parts is available for this project.
Order As LK03D. **Price £9.95**

power outputs are required, and this may make transformers difficult to find. Alternatively, two separate PSUs may be used, one for each amplifier, but they must track each other closely to avoid signal amplitude errors between amplifiers at full power outputs.

Circuit Description

Both amplifier signal outputs are present on pins 1 and 6, which are mixed, then amplified by IC1. As both signals are out-of-phase with each other the expected output of IC1 will be close to 0V. If one signal input has a DC offset, or has no signal at all, the the output from IC1 will be presented to either TR1 or TR2. TR1 will only conduct to positive signals, and TR2 will only conduct to negative signals, with reference to 0V. TR3 inverts TR2 output, and, when conducting, pulls TR1 collector down from the positive supply rail to 0V, via potential divider R12 and R13.

IC2a switches to C/R timer C2/R16, and gives a three second turn-on delay, preventing IC2a, b, and d from changing state, and thus holding TR4 off. RLA will not operate during the timing period and a loudspeaker connected between pins 3 and 5 (RLA) will be out of circuit. When IC2c output finally goes high IC2b output will switch high and slowly charge C9. IC2a will switch high before C9 has fully charged, and D6 will conduct, causing IC2b output to change state to 0V and latch IC2a in a high state.

TR4 will now turn on and RLA will operate, presenting the loudspeaker to both amplifier outputs. If a fault condition turns on TR1 or TR3, IC2d output will switch high and D5 will conduct. IC2a output goes low and RLA will be released. IC2b then switches high, latching IC2a and holding TR4 off until reset by connecting pins 20 and 21 together. IC3c is a high impedance unity gain input buffer and IC3d is a low pass filter.

Our MOSFET amp has a large power bandwidth of some 70 to 100kHz or more, and for audio use it is not desirable to reproduce high power levels at these frequencies, so a low pass filter, IC3d has been added with a cut off frequency of 25kHz and a slope characteristic of 12dB per octave. This prevents h.f. signals from being amplified by reducing their level above the cut off point. IC3a is a unity gain buffer producing a signal output at pin 13 in phase with the pin 11 input signal, while IC3b inverts and produces a unity gain signal 180 degrees out-of-phase with the input, at pin 15. The two signal outputs are then connected to both MOSFET amp inputs (figure 5).

Construction

Insert all six diodes, noting that D3 and D4 are different from the others. They all have a band on one end, which must align with the band on the legend. Insert all resistors and both preset potentiometers, followed by all the capacitors. C3 and C4 are electrolytics, while C2, 5, and 9 are tantalum beads, and they all have polarity markings at one end. Mount the four transistors and three IC sockets, followed by the 21 vero pins. The relay is fitted last, and goes directly into the PCB. Bend the terminals over their track pads to hold in place. Solder all connections carefully and clean excess flux etc. from the board. Inspect the track face, looking for bad joints or short circuits, then fit all three ICs in their sockets.

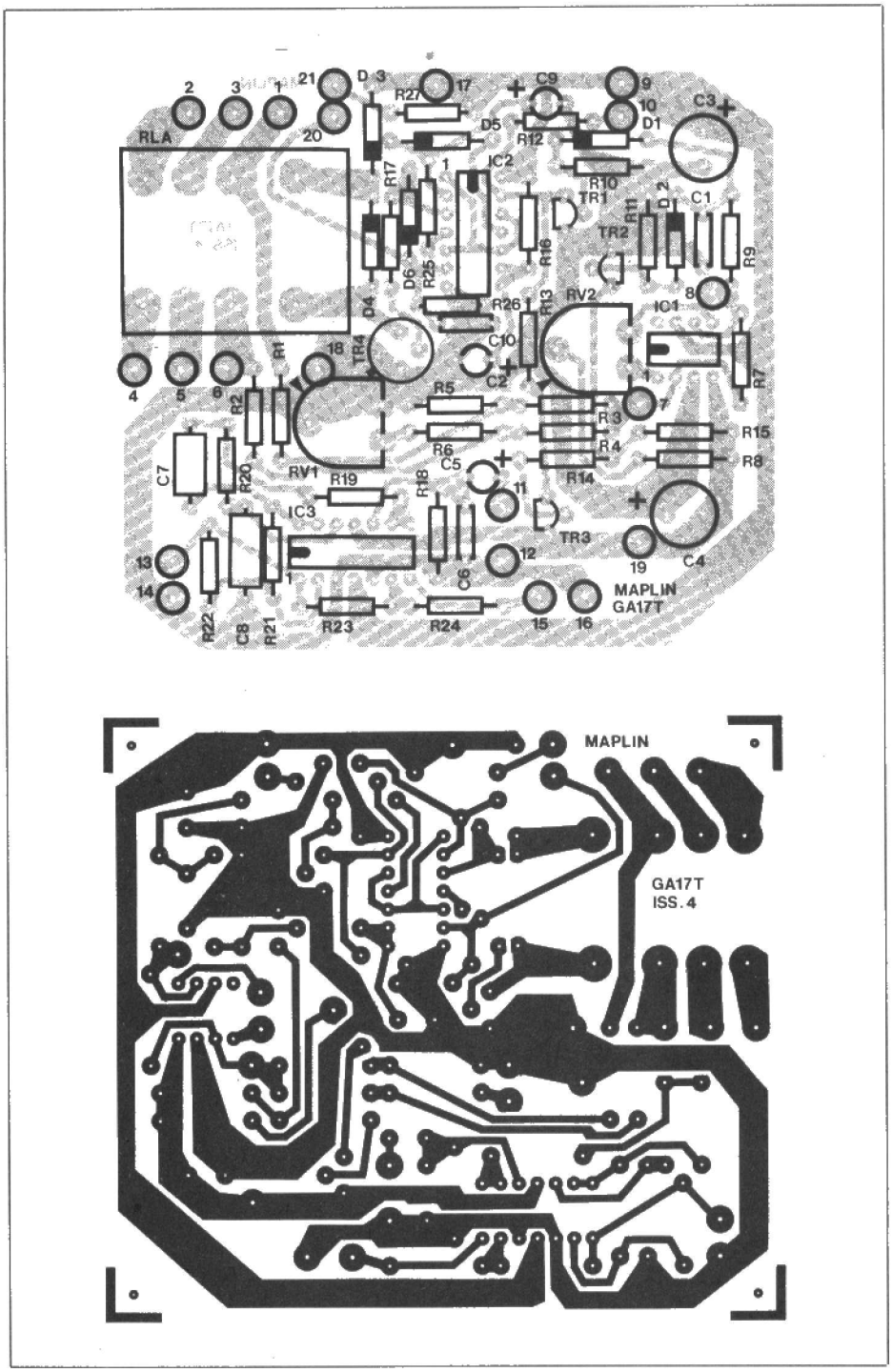


Figure 4. Legend and artwork.

Test and Use

Connect LED 1 between pins 9 and 10. The anode (positive) leg is usually the longest, and goes to pin 9. Turn RV1 and RV2 wipers so that their centres line up with the arrows on the legend. The indicators have been added for guidance purposes only, and are not final adjustment positions.

Temporarily connect pin 13 to pin 1 and pin 15 to pin 6. You will need a 50Hz signal source for setting up the null point and also a voltmeter, or preferably an oscilloscope.

Connect a +12V to +15V power supply to pins 17, 18, and 19 as shown in figure 5, and switch on. RLA should operate after about three seconds. Place a DC voltmeter between 0V and pin 8. Adjust RV2 for a reading of 0V.

Set the voltmeter to read 1V AC, and connect between 0V and pin 11. Also connect a signal source to pin 11 and 12V, and adjust the signal to 50Hz and about 1V RMS (3V pk on a scope). If you are unable to do this don't worry, as adjustments can be made further on, when using the complete system. Remove the meter lead from pin 11 and

reconnect to pin 8. Adjust RV1 for the lowest possible voltage, which will appear as a dip in the reading.

If using a scope, adjust RV1 for null or 0V, whichever is the least. Switch off power and remove connections from pins 1, 6, 13, and 15, and the voltmeter.

Wire the bridging module to both MOSFET amps as shown in figure 5, but do not connect a speaker yet. Use screened lead for all signal connections. Connect power supplies and switch on. Apply a music signal, or whatever you intend to normally use the system for. Remove signal wire from pin 13, and RLA will release. It can be reset by briefly shorting pins 20 and 21 together. LED 1 also acts as a peak level indicator, coming on if signal levels reach clipping point at the output. RLA will also operate if this happens. Reconnect signal wire to pin 13 and remove the other input wire from pin 15. Again, RLA will release. Reconnect pin 15 to your amplifier and all will be ready to go.

The module pre-amp stages are exactly unity gain, and up to a maximum signal input level of about 10V RMS can be handled, although the power amps would complain! Their maximum input for full output is 1.2V RMS, and levels greater than this will clip the output.

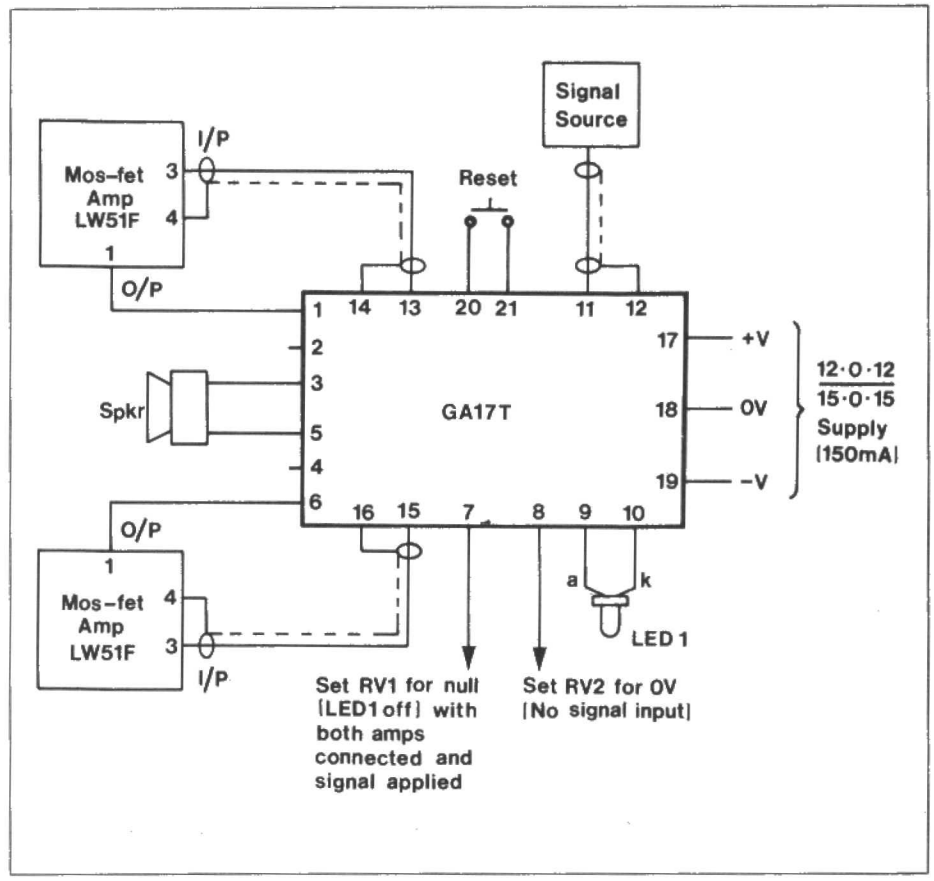


Figure 5. Connections for two amplifiers and bridge module.

FIRST BASE continued from page 21

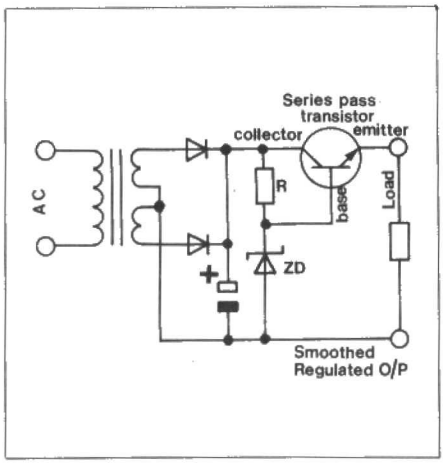


Figure 9. Use of a series pass transistor.

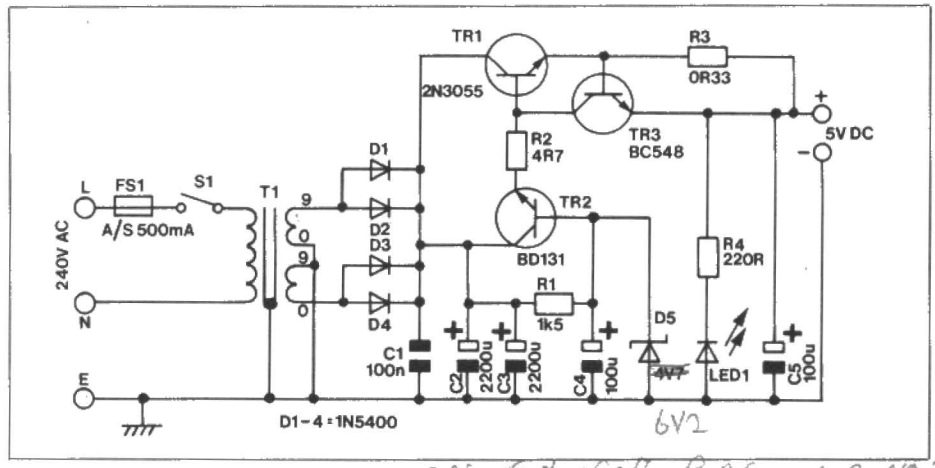


Figure 10. PSU circuit.

P.S.U. PARTS LIST

Resistors – All 0.4W 1% metal film unless specified.

R1	1k5		(M1K5)
R2	4R7 (½W 5%) carbon		(B4R7)
R3	0.33R (3W) wirewound		(WO33R)
R4	220R		(M220R)

Capacitors

C1	100nF disc ceramic		(BX03D)
C2,3	2200uF 16V PC electrolytic	2 off	(FF60Q)
C4,5	100uF 10V PC electrolytic	2 off	(FF10L)

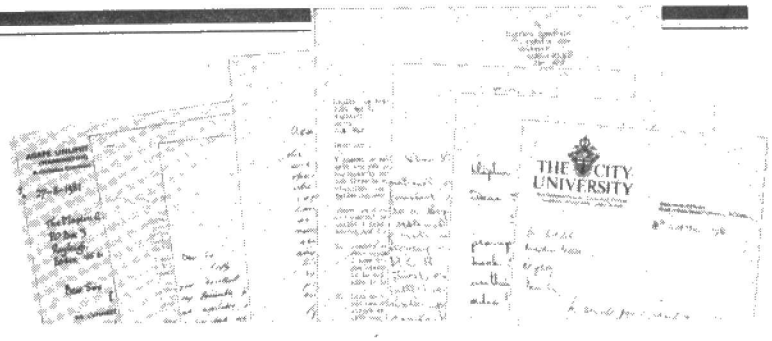
Semiconductors

D1-4 inc	1N5400	4 off	(QL81C)
D5	BZY88C6V2		(QH09K)
LED 1	Red LED		(WL27E)
TR1	2N3055		(BL45Y)
TR2	BD131		(QF03D)
TR3	BC548		(QB73Q)

Miscellaneous

T1	TR 9V 1½A	(WB03D)
FS1	500mA A/S	(WR18U)
S1	Std Toggle SPST	(FH10L)
	Safe fuseholder 20	(RX96E)
	Kit T03	(WR24B)
	Wire to suit	

READERS LETTERS



Bouquets and Brickbats

Dear Sirs,
After much delay herewith some brief bouquets and brickbats from one of your regular customers.
1. I think your service, mail and phone is superb. When phoning it is wonderful to speak to someone pleasant, helpful, and intelligent — a rare combination these days. Keep it up! Also, the reply-paid envelope is a tremendous blessing — without it you might well lose a lot of orders just because of the sheer hassle of finding and addressing an envelope. In short, you've got it right.
2. I must confess to being slightly disappointed with the new catalogue. It's OK, but a supplement to the previous one might have done. Dare I mention loose-leaf again?
3. Could not the price list be produced in alphanumeric order, rather than page order? It would surely be easier for you — since the info must come from your computer system — and I'm sure customers would find it easier to use. I mean alphanumeric order of your ordering codes, of course.
4. Why on earth have we had to get caught up in a new resistor colour code, when the industry standard code does all that is necessary? I nearly returned the last order to you, thinking Maplin had fallen on its face, until I realised at the last moment what had happened. I dread to think of the confusion it must cause some people. Black mark to Maplin.
Keep up the good straightforward service, and a happy and successful New Year to all at Maplin.

H. C. BURFORD
Ryde, Isle of Wight

1. Many thanks for your comments, though a lot of customers have had a problem recently getting through to our sales desk. These phones have been incredibly busy, but if you get ringing, do hang on. We changed our phone system recently and whereas in the past you were answered and then had to hang on if sales were busy, under the new system your call enters a queue and you are answered in the order in which the calls arrived. The advantage to you, of course, is that there is no phone charge whilst you're hanging on, but you are in the queue just as you were before. However, by the time you read this our extra sales telephones may be operational and the problem relieved.
2. A catalogue supplement is difficult to use as you then have to look in two places for your choice of a particular type of item. Loose-leaf is a good idea, but just too expensive.
3. We are very much against having the price list in alphanumeric order since it becomes very difficult to compare prices of similar items. Hopefully, however, our next catalogue due in November this year will have the prices printed on the page.
4. Unfortunately the five-band colour code is the international standard for 1% tolerance resistors. It has been the standard in industry for many years, but hobbyists will not have seen it much due to the previously prohibitively high cost of close tolerance resistors. But I have to agree that it's a blessed nuisance having to relearn resistor colour codes. The price of progress, I suppose.

CB Projects

Dear Sir,
Re: Chris Walker's letter, letters page Nov-Feb price list.
I, too, as probably many other people, subscribed to the Maplin magazine "Electronics" on the strength of the 27MHz CB project and am most disappointed that it was not printed. However, I do see the logic of not including it due to the massive slump in CB rig prices which I think has caught everyone by surprise, including me. Why, though, should you leave people like me, who haven't had the time or money to take the RAE examination, without radio projects for CB. I am sure that there would be a great deal of interest if Maplin were to publish a 934MHz band project for which the transceivers now made are either very hard to get or extremely expensive. This band has been entirely neglected since its announcement and one suspects left for the elite few. I understand that the range attainable with this equipment will be quite small despite the more efficient aerial systems, but in built-up areas after working hours (and not at 3.30 a.m.) the range on standard 27MHz is very small (about 2 miles at the very maximum in my area), if one does not resort to illegal power amplifiers. So come on, Maplin, stop giving us dull Ultrasonic intruder projects for the 25,000,000th time (in the electronic press) or computer controlled railway systems and give us something we can get our teeth into (although we might need burglar alarms if we get a 934MHz band transceiver by the way availability is going at present).

H. JAREMKO

The problem with a project to build a CB transceiver at 934MHz is that the standard of construction will have to be exceptionally high for the project to work. Remember that a kink in a wire is a tuned circuit at these frequencies. Our technical editors think that it is beyond the capabilities of the average constructor. Not only that, but some very sophisticated test gear will be required to align it and ensure it is working correctly. Very few people will have access to such test gear. The only possibility is if we produced ready-made pre-aligned modules for the rf stages and let you build the rest. We'll have a look at the possibility of doing that. We were surprised to read your comment about the RAE exam. This is not very expensive to take and since it consists only of choosing the correct answer out of a list of possible answers for each question, anyone capable of making and faulting on a 934MHz transceiver should be able to pass with no problem at all. Once you've passed, of course, the equipment and frequencies you can use far exceeds anything possible with CB.

Knowledge In The Wrong Hands

Dear Sir,
Having read Chris Walker's letter in your December/February edition I feel that to an extent that I must agree with some of his comments regarding the publication (or not as the case is) of the 2m/CB project. However, I sincerely trust that the Maplin Magazine is not going to lower itself by following so many other electronics based magazines and become another pseudo-CB publication. Very few CB operators and potential CB operators have either the knowledge or the equipment to construct satisfactory transceivers within the legal specification, and those that are capable are either in the communications industry or are licenced amateur band operators who are probably sick at the idea of constructing/testing a project like that. The infered suggestion in your reply to Chris Walker's letter that you are going to publish a major transceiver project in a forthcoming issue makes me wonder just how much more illegal transmission such magazines as yours will allow before you realise that a lot of knowledge in the wrong (unqualified/unlicenced?) hands can spell serious problems for authorised users of certain frequency bands. E.g. Fire and Police radio which is just above the 2m band, Ambulance service which is third harmonic of parts of 27MHz band, etc.
However, I do appreciate the majority of contents of your magazine and, although contradicting myself to an extent, would like to see the publication of a 2m synthesiser article including the 600KHz repeater shift facility.

N. R. NEGUS
(Home Office Telecoms Engineer)
Gloucester

Whilst we would be the last to advocate illegal transmissions, we do feel that there are a lot of licensed amateurs who would enjoy building a well-designed transceiver. We would almost certainly supply the rf transmitter stage as a ready-built pre-aligned module, so this should eliminate interference problems which might otherwise arise. In the end I think it would really be up to us to produce a high quality design which was easy enough to build and sufficiently well documented that it could be built without causing problems to others.

Atari vs BBC

Dear Sir,
I have been amused, and rather irritated by your recent newsletter correspondence concerning the Atari vs BBC computer.
I was stunned by such sweeping generalisations as "for home use the Atari is a much better proposition". On what basis do you make this statement? In my opinion, whoever wrote that is either ignorant or stupid or both.
Computers are essentially for programming — not for making pretty pictures! There can be no denying that the Atari has 256 "hues" available, when the BBC Micro has only 8 colours (not colors!), but can the Atari handle recursive procedures with local variables, or complex (conditional) machine code macro-assembly? Does it support structures such as Repeat/Until, or If/Then/Else?
As regards your comment about languages ("the others [Unix, Fortran, Cobol] are not suitable for home use") — what is this gross generalisation supposed to mean anyway? No, Fortran and Cobol (at least the standard versions) are not suitable for playing Space Invaders — but they put to shame even the amazingly advanced BASIC of the BBC Micro, for programming power. Lastly, Unix is not a language, but an operating system, and is, by definition, suitable for any system on which it is implemented. Check your facts before generalising!
As to the "extra chips" in the Atari machine: Do you honestly believe that all the BBC graphics and sound capabilities are handled by one (albeit 2MHz) 6502? Again, you have not checked your facts.
The BBC Micro has a custom designed ULA (uncommitted logic array) which handles graphics — making possible the excellent "palette" facilities, and a separate 4-channel sound generator, with an interrupt-driven queue, enabling processing to continue while sounds are being made.
Finally, your last comment in your reply to Mr Grimley Evans ("don't expect the basic machine . . .") is simply RUBBISH. I've used both, extensively, and in my opinion, the *only* ways in which the Atari is superior are the larger number of colours, and in sprite graphics ("player missile" graphics to Atari — that sums it up!), and this latter can be achieved on the BBC by considered use of the "palette" facility.
Please, Maplin, your customers expect better of you than the Sinclair trick of degrading other peoples' products on inaccurate or incomplete information. If you sold the best computer on the market, you would have no problem advertising!

GERAINT A. WIGGINS
Corpus Christi College, Cambridge

We are not swayed by this letter from our opinion that the Atari is a better computer for home use than the BBC. Calling us ignorant or stupid does not alter the facts. You are quite right when you say that computers are for programming, but the most interesting programs are those which make the computer do something. The fact is that there is more hardware in the Atari for your programs to talk to, so your programs can do more interesting things. The BBC may have a ULA, but this is just an array of logic functions. In its place the Atari has a second real microprocessor driven by its own program and yet another dedicated chip to deal with the player/missiles or sprites.
We would be the first to admit that the BASIC supplied with the Atari is not

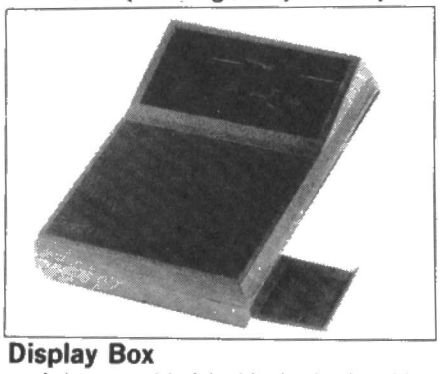
MAPLIN NEWS

Two Battery Holders

A pair of battery holders to supplement the range shown on page 27 of our catalogue. One to hold a single 'C' type cell and one to hold a single 'D' type cell, both with solder-to-tag connections. Sizes are 61 x 28 x 25mm for the 'C' type and 69 x 35 x 27mm for the 'D' type.

Order As

BK45Y (HP11 Single Box) Price 19p
BK46A (HP2 Single Box) Price 19p



Display Box

A box moulded in black plastic with a clip-on battery cover. The case is snap-together, and is ideal for projects which need to be hand-held. Dimensions are: 110mm long x 80mm wide x 30mm high at the rear and 21mm high at the front.

Order As HY25C (Display Box) Price 50p

Echo Machine EM-006

A high quality echo chamber using solid state bucket-brigade delay lines. The unit is finished in matt black, and the inputs are standard mono jack sockets. The MIC socket is the input jack for low impedance (-46dB/10k), and the INSTRUMENT socket is the input for an instrument or line output of hi-fi, organ, synthesizer etc. (-20dB/220k). There is a footswitch jack on the rear for a remote control switch.

The delay time control is variable between 20 and 200msec, and there are three selections of output level (0, -20, and -40dB) to enable connection to any amplifier. There is also a peak level indicator, which will show when the input level is excessive and likely to cause distortion.

The balance control sets the mixture of echo and straight through sounds, with no echo at 'direct', total echo at 'delay', and even at the centre position. The repeat control sets the number of repetitions of echo sound, the dial being rotated clockwise to increase the repetitions.

Overall size: 220 x 150 x 55mm.

Order As XG30H (BBD Echo EM-006) Price £55.00

NEW ITEMS SINCE CATALOGUE

BK66W	Modulator UM1286	**Price £11.90**
BK67X	Moisture Scale	**Price £0.20**
GA16S	Panic Button PCB	**Price £1.25**
GA17T	MOS-Amp Bridge PCB	**Price £1.96**
GA69A	Programmable Timer PCB	**Price £1.49**
GB09K	Modem Main PCB	**Price £4.99**
GB10L	Modem PSU PCB	**Price £1.75**
GB11M	Sound Generator PCB	**Price £2.25**
GB12N	Inverter PCB	**Price £1.99**
GB13P	Scratch Filter PCB	**Price £1.99**
GB14Q	ZX81 TV Sound/Inverse Video PCB	**Price £2.20**
GB17T	VIC 20 Talkback PCB	**Price £3.36**
GB18U	ZX81 Talkback PCB	**Price £2.25**
LK00A	VIC20 Talkback Kit	**Price £24.95**
LK01B	ZX81 Talkback Kit	**Price £24.95**
LK02C	ZX81 TV Sound and Inverse Video Kit	**Price £29.50**
LK03D	MOSFET Bridging Amp Kit	**Price £9.95**
LK04E	Scratch Filter Kit	**Price £24.90**
LW95D	Inverter Kit	**Price £49.95**
LW96E	Sound Generator Kit	**Price £10.95**
LW97F	Panic Button Kit	**Price £4.50**
LW98G	Programmable Timer Kit	**Price £6.95**
LW99H	Modem Kit	**Price £39.95**
QQ39N	4412VP	**Price £8.00**
QY43W	XR2211CP	**Price £4.45**
QY50E	SP0256	**Price £8.98**
XG29G	Inverter Transformer	**Price £22.50**

Readers' Letters continued

the most brilliant BASIC in the world. That does not mean that a good BASIC would not be able to do what you said. After all, it is exactly the same microprocessor (6502) in both Atari and BBC. In fact, BASIC A+ does support structured programming and Atari Microsoft BASIC is also far superior to Atari's basic BASIC. Equally Atari's Macro Assembler is a very powerful piece of software. But in the end, even if the programs you write look nicer on the BBC than on the Atari, they cannot do as much as they would on the Atari because there just isn't as much hardware in the machine to do interesting things with. My comment about Unix, Fortran, Cobol etc. did not imply that they were all languages; I said that they were large pieces of software, and they are not suitable for home use because for example a half decent Fortran compiler would fill all the RAM in an 8-bit micro before you started to write a program. The same applies to Cobol. It would be nice to be able to run programs that use Unix, but having loaded the operating system, how much room would be left for the program? The answer is: very little.

The graphics features that you mention as available on the BBC are included on the Atari, but are relatively minor features in comparison to the special capabilities of the video processor in the Atari. The Atari can have its own second machine code program running simultaneously with, but completely unseen by the main BASIC or machine code program and linked to the 50Hz TV frame rate via the video processor's interrupt system. The Atari could for instance move (rotate, pan in and out, scroll through etc.) a complex three-dimensional colour picture while the main program gets on with other work. Such complex, time critical calculations and processing can occur without disturbing the main program. Real time sharing on your own home micro!

Finally, let's look at your strange comment that "computers are essentially for programming — not making pretty pictures!" To produce anything meaningful, a computer must communicate with its user. Our eyes can assimilate vastly more information than any other of our senses, so any computer that can transfer its results by means of pictures is going to be far more interesting to interact with. This is probably not important in the office or schoolroom where it is the printed results that matter. But at home instead of writing purely academic programs on the BBC, you can write programs on the Atari that will actually produce visually meaningful results as well as printed results. It may well be that the BASIC listing will look prettier on the BBC, but it won't do as much on the BBC as on the Atari, because it doesn't have the hardware to do it. And that's a fact! That's why we stand by our original statement. We are convinced that after carefully considering all the relevant points, the Atari stands out as the best computer available at the moment for home use.

If you have any interesting comments to make about your hobby in general or Maplin in particular then please write to: The Editor, Maplin Mag, P.O. Box 3, Rayleigh, Essex SS6 8LR. Please write clearly and keep your letters brief and to the point. Thank you.

MAPLIN MOISTURE METER

by Robert Kirsch

- ★ **Low cost**
- ★ **Simple to use**
- ★ **May be used on wood, brick, plaster, etc**
- ★ **Built-in calibration**

The Maplin Moisture Meter is an electrically very simple instrument that enables the moisture content of various materials to be measured. The Moisture Meter has a function similar to damp meters of the type used by surveyors and builders. Its chief use is to detect dampness and rot in buildings, so that immediate remedial measures can be taken before irreparable damage occurs. Other uses include determining whether a wall is in a suitable condition for hanging wallpaper or painting, and these are explored in more depth later in this article.

Circuit Description

The circuit is shown in Figure 1, and it will be noted that the device is basically an ohmmeter using a transistor to make it more sensitive than the type found in an ordinary multimeter. TR1 forms a standard common emitter amplifier, whose gain is mainly determined by the collector load R1 and RV1. The gain is adjusted by RV1 to compensate for transistor tolerances, battery voltages, and thermal effects in the transistor before use.

The voltage drop across the collector load is measured by the meter M1, whose full scale deflection is set by the variable resistor RV2 and R2. R3 forms a meter shunt to help damp the meter movement.

The base of TR1 is fed via R4 to S1a, which selects the two calibrate and one working mode of the instrument. In position A the transistor is biassed hard on, and at this point full scale deflection is set by adjusting RV1 so that the meter reads cal A.

When the switch is in position B the transistor gain is set by RV2 so that the meter reads cal B. The fourth position of the switch connects the test probes to the base circuit of the transistor, which is then biassed to a point dependant on the resistance of the surface being tested.

Construction

There is no PCB in this design, and the components may be assembled as shown in Figure 2, taking care to sleeve all component leads to prevent short circuits. Ensure the transistor, meter, and battery are all connected with the correct polarities.

The probes may be made from any sharp steel needles, and should be as fine as practical to prevent damage to tested surfaces. The points from ordinary darts have been found very satisfactory. These may be arranged to form a single unit or used as separate probes, but in both cases remember that in use they must be inserted one inch apart.

A new self-adhesive scale (BK67X) is available for the meter (RX54J), and this should be fitted as follows:

Remove carefully the plastic front of the meter and undo the two screws holding the scale to the meter body, noting roughly the positions of the two end stops. Remove the scale plate from

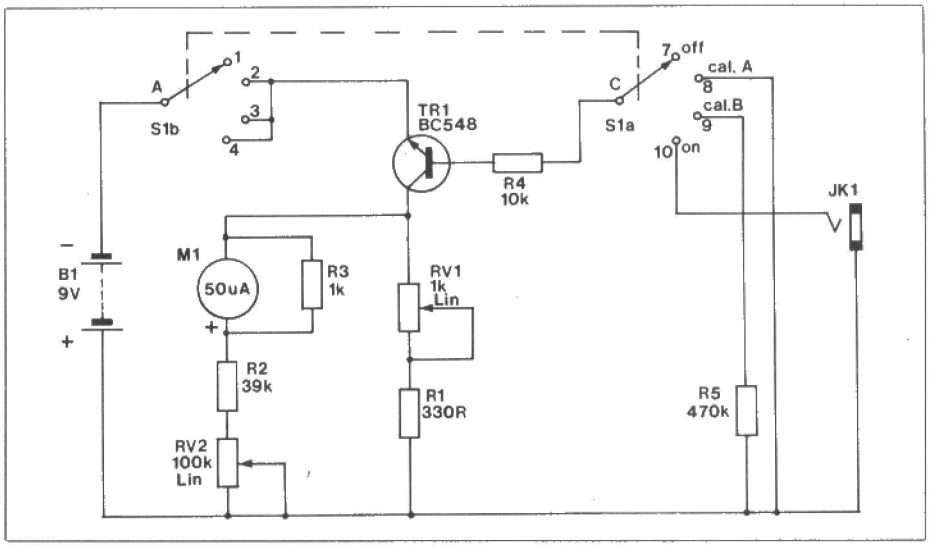


Figure 1. Circuit diagram.

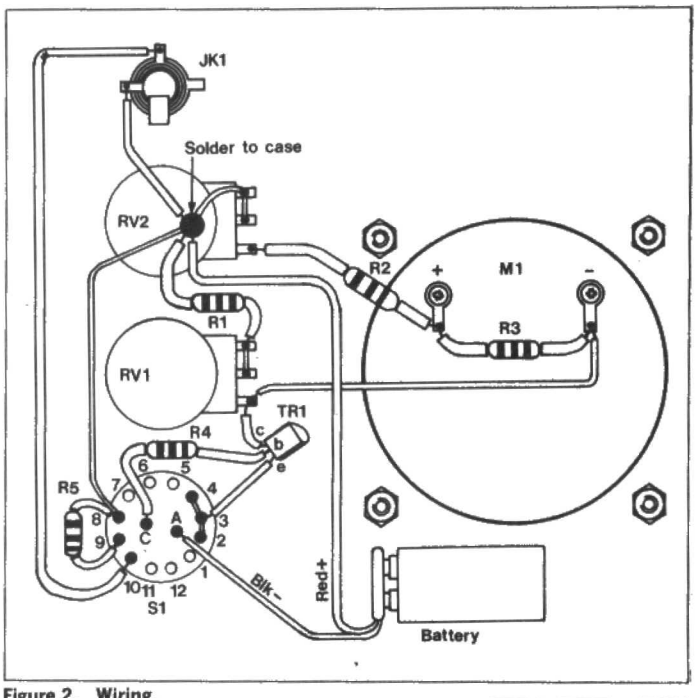


Figure 2. Wiring.

MOISTURE METER PARTS LIST

Resistors — All 0.4W 1% metal film unless specified.

R1	330R		(M330R)
R2	39k		(M39K)
R3	1k0		(M1K)
R4	10k		(M10K)
R5	470k		(M470K)
RV1	1k0 lin pot		(FW00A)
RV2	100k lin pot		(FW05F)
Semiconductors			
TR1	BC548		(QB73Q)
Miscellaneous			
S1	Switch (Rotary Sw 6B)		(FF74R)
JK1	Jack skt 3.5		(HF82D)
PL1	Plug plas. 3-5		(HF80B)
M1	Meter		(RX54J)
	PP3 clip		(HF28F)
	Potting box small		(LH57M)
	Moisture scale		(BK67X)
	Cable single black (2 metres)		(XR12N)
	Wire (Hook-up) black (as req.)		(BL00A)
	Potting compound		(LQ02C)
	Isonuts M3	1 pkt	(BF58N)
	Isoshake M3	1 pkt	(BF44X)
	Systoflex 2mm black	1 metre	(BH06G)
	Box AB13		(LF14Q)
	Knob K10A	3 off	(RK89W)

the meter, taking care not to bend or damage the needle assembly. Remove the backing from the new scale and align it with the scale plate, pressing it down from one edge to the other and ensuring that no air bubbles are formed.

Reassemble the scale plate to the meter body, checking that the needle end stops are in the correct position by gently blowing the meter needle to its extremes and making sure that these are just beyond the extreme markings on the scale. The end stops should be adjusted if necessary before tightening the screws. Replace the front cover.

Calibration

The meter calibration should be checked before use. This is accomplished as follows:

1. With S1 to OFF check the zero reading of the meter and adjust the screw on the meter front if necessary.
2. With S1 to A adjust RV1 until the meter reads Cal A on the scale.
3. With S1 to B adjust RV2 until the meter reads Cal B on the scale.
4. Switch to ON. The meter is now ready for use.

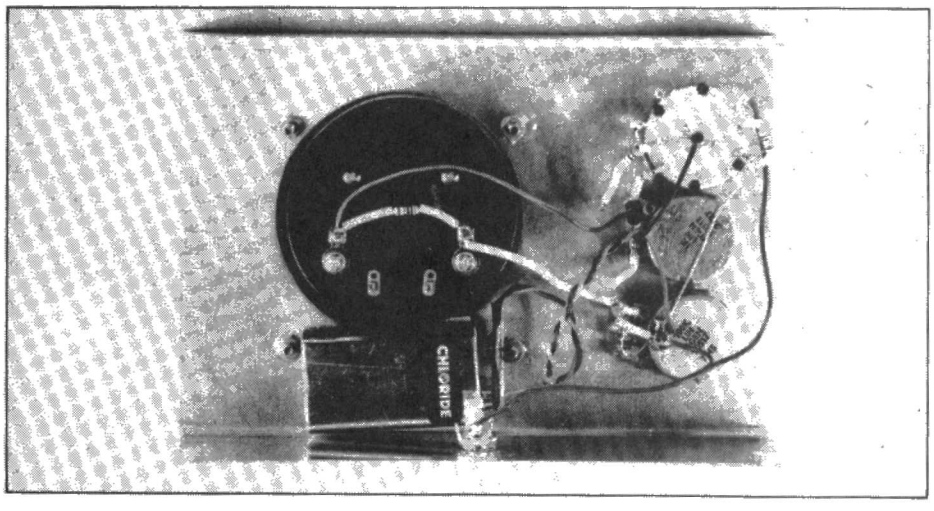
If these readings cannot be obtained a new battery may be required.

Use

The meter is used by pressing the two probes hard onto the surface under test, and holding them about one inch apart. The reading should then be taken from the appropriate scale. The tips of the probes should enter about a quarter inch into wood, if it is the surface under test. If there is heavy condensation then the surface should be wiped dry before taking measurements.

Scales

Any surface may be considered dry if the needle does not move from zero, or is less than 0.1 on the reference scale.



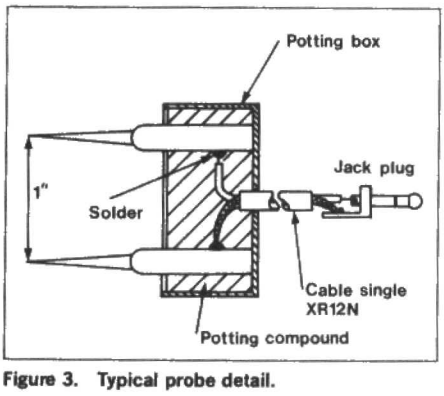


Figure 3. Typical probe detail.

Wood

The normal moisture content of timber varies with the temperature and type of wood. The upper two scales (WOOD 1 and 2) are used to test the following types of wood:

WOOD 1: Close grain types, e.g. ash, oak, beech, douglas fir. These woods are often found in older properties.

WOOD 2: Open grain timber, e.g. whitewood, redwood, deal.

A normal reading for wood is about 10 to 12% in heated locations and 15% in unheated locations. Any reading above normal could indicate dampness problems, any new timber may begin to deteriorate if left untreated when it is above this level. Dry rot can thrive in wood with a moisture content of 18% or above. When the reading is above 28% the wood has reached fibre saturation point, and this is marked on the scale as 'F.S.P.'

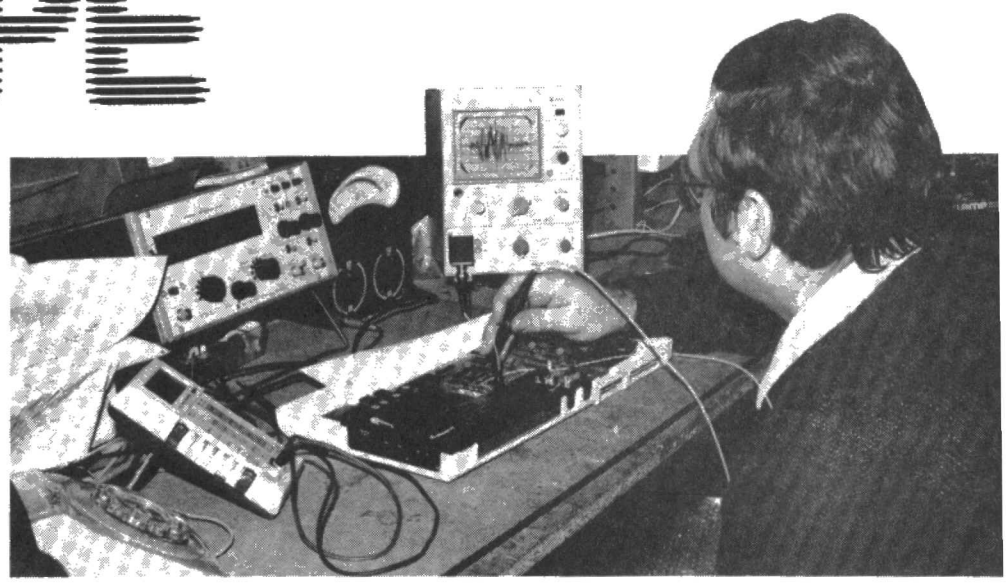
Reference

The reference scale is used as a guide to the moisture content of brick, plaster, concrete, and various building materials, although some types of building blocks have a high carbon content, and therefore will not give a true reading. If there is any doubt a known dry sample should be tested to make sure that no reading is obtained. The source of dampness may be found by taking several readings and noting the area(s) in which the highest reading occurs, this being nearest the source of moisture.

A surface reading of 1.5 on the reference scale indicates that the surface may be painted with emulsion or water-based paints, and a surface reading below 0.5 may be covered with oil-based paints. Any reading above 2 should definitely not be painted.

WITHIN YOUR SCOPE

by Paul Harding



The Cathode Ray Oscilloscope (CRO), or scope, is probably the most useful of all the instruments available to the electronics enthusiast, professional or amateur. For, although its accuracy is not very great, it can serve as an AC or DC voltmeter, a time and frequency meter, a phasemeter, and, with a few extra components, a current and power meter. This flexibility in use is what makes the CRO so important in all fields of electronics, from DC power supplies to RF communications. So why haven't we all got one? The main reason, as usual, is the cost. Until recently there have been few CROs available for under about £350, and this is too expensive for all but the most enthusiastic amateurs. However, in the last couple of years several manufacturers have done their best to fill the gap in the market, and have produced instruments which fit the needs and the pocket of the electronics hobbyist. This article has been written as an introduction to what a CRO is, how to use it, and what it can do for you.

The Cathode Ray Tube

Although a modern (and expensive) professional oscilloscope may look very complicated, and have extra features not found on cheaper ones, all scopes consist of the same basic units, as shown in figure 1. The most important part of the scope is the cathode ray tube (CRT). This consists of four main parts: the cathode filament, the accelerator, the plates, and the screen. The CRT works by producing electrons at the hot cathode and forming them into a narrow beam, which is aimed at the fluorescent screen through deflection plates. By varying the electric potential of the deflection plates, the beam can be bent to produce a small fluorescent dot on the screen. This 'bending' of the beam can be done very fast to produce an apparently continuous line or 'trace' on the screen. This is exactly the same technique as that used to produce a TV picture, although the beam bending is usually done electromagnetically with a TV CRT. The trace on most general CROs is usually green. This is because the phosphor with the highest brightness, known as P31, gives off green light, although other phosphors, used for special purposes, can be different colours. The part of the tube that produces the electron beam is often called the electron gun, as it literally 'fires' electrons at the screen. As many modern scopes display two or more traces, it is necessary to have either more electron guns, or, more commonly, to switch the beam from one trace to the other so fast that the effect cannot be seen on the display. More of this later.

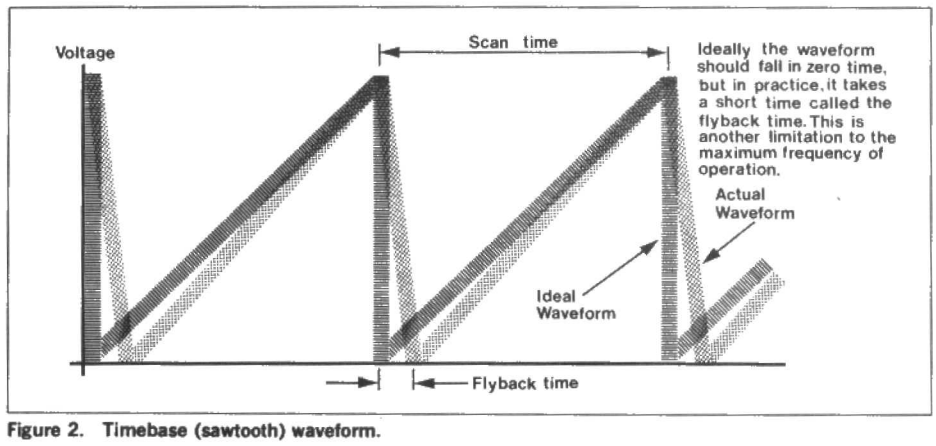

Voltage
Scan time
Ideally the waveform should fall in zero time, but in practice, it takes a short time called the flyback time. This is another limitation to the maximum frequency of operation.
Actual Waveform
Ideal Waveform
Flyback time

Figure 2. Timebase (sawtooth) waveform.

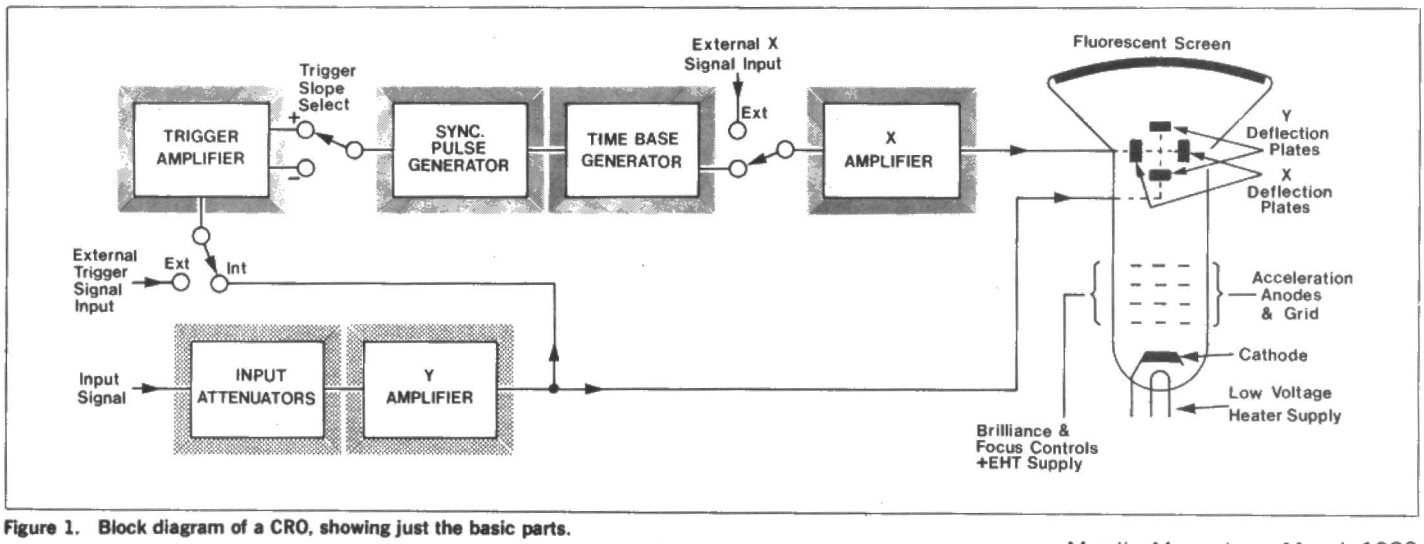
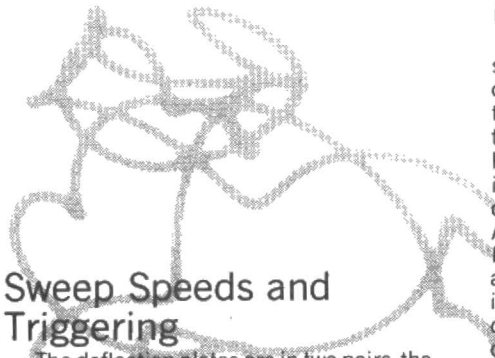


Figure 1. Block diagram of a CRO, showing just the basic parts.



Sweep Speeds and Triggering

The deflection plates are in two pairs, the X pair for horizontal deflection and the Y pair for vertical deflection. The Y plates are fed with a voltage from the Y amplifier which is proportional to the signal applied to the input. This in turn moves the electron beam a distance proportional to the voltage plates, because the voltage needed by the deflection plates is usually around 100V, and the signal of interest may only be 10mV, so a voltage gain of around 10,000 is required of the Y amplifier. This amplifier must also have a bandwidth at least as great as the maximum frequency of operation, i.e. a 100MHz CRO must have 0-100MHz bandwidth amplifiers. Anyone who has built a wideband amplifier will know the many difficulties and understand why the cost of scopes increases dramatically with bandwidth.

The X amplifier is similar to the Y amplifier, but in normal use it is fed with a different type of signal, known as a timebase. The timebase signal is a voltage waveform that increases proportionally with time, moving the electron beam across the screen at a steady rate. When the beam has crossed the screen the voltage is reduced quickly and the beam returns to the left, ready to start its next sweep. This waveform is shown in figure 2, and is a sawtooth waveform. A selector switch on the front panel varies the frequency of the sawtooth, which in turn varies the sweep speed. The speed is usually variable in steps from about 1cm/s to 1cm/us using this control. Thus, by applying a signal proportional to the input voltage to the Y plates, and a signal proportional to time to the X plates, a graph of voltage against time is displayed on the screen. Without additional circuitry the display would not be stable, and it would be difficult to see the displayed waveform.

It is necessary to synchronise the timebase with some point on the input waveform, i.e. the timebase starts its sweep across the screen at exactly the same point each time. The circuit which does this is called the trigger. Trigger circuits usually give the operator a choice of different operating modes; Internal, External, Line and TV are those usually found on moderately priced scopes. The essential difference between each mode is the source of the trigger signal. When internal is used the trigger signal is derived from the input signal, but external operation requires the input of the trigger signal to the external trigger socket on the scope.

TV triggering is a special purpose trigger normally used only when examining video signals at frame frequency. Line triggering uses the mains frequency as the synchronisation signal, and is useful when looking at ripple and hum waveforms that are at mains frequency. Most scopes also offer an automatic trigger position, which sets the trigger level for normal operation. When auto is not in use the trigger level will have to be set manually for the most stable display, using the trigger level control.

Display Methods

As previously mentioned, most modern scopes have two separate traces, usually derived from one electron gun. The electronic switching to obtain two traces takes two different forms, ALTERNATE and CHOPPED operation. The choice is left to the individual, as both have advantages over the other, hence the appearance of the CHOP/ALT switch as part of display mode controls. In alternate mode the upper and lower traces are scanned alternately (hence the name) i.e. the signal applied to channel one is displayed in one sweep time and then channel two waveform is displayed in the next. The vertical positions of the two traces can be altered of each other, allowing waveforms to be compared directly on top of each other if necessary. This mode of operation has the disadvantage of not necessarily displaying both signals in correct time relationship, i.e. two signals that are occurring at the same time may appear slightly displaced when alternate scanning is used. This is not a problem with chopped mode.

Instead of displaying a whole trace of one channel, then the other, as in alternate mode, a small part of one trace is displayed, then a small of the other. This continues until both traces are fully displayed. Thus the two traces are displayed together, and no distortion of the time relationship is possible. The main disadvantage of chopped operation is that for a good clear display the 'chopping frequency' should be at least 100 times greater than the frequency to be displayed. As the chopping rate is normally fixed, this limits the maximum frequency at which it can be used. Exceeding this limitation results in the waveforms appearing as a series of dashes on the screen.

To use a scope as a measuring instrument the calibration of the scale must be known. The scale is usually a grid of 1cm squares, with units of volts per cm vertically and seconds per cm horizontally. Both are variable, either in steps or continuously, giving typical scales of 50V to 10mV per cm and 5sec to 0-1 us. The time and voltage divisions are calibrated during manufacture, and the manufacturers data should be studied to obtain accuracy figures for the scope in use. For the majority of scopes ±3% of the displayed value is typical, and this should be remembered when deciding whether or not to use a scope for a particular measurement. As an example, if the display on the tube is 3cm high and the vertical amplifier is set to 1V per cm, the signal has an amplitude of 3V ± 3%. Note that there is often additional error caused by the thickness of the trace, therefore there is no point in measuring the height of the waveform as 3.125cm when the thickness of the trace is likely to be about 0.05cm. The focus and brightness controls should be set to produce a fine and clear line to minimise this form of error. An important point to remember is that excessive brightness can cause the phosphor on the screen to 'burn', producing dark spots on the screen which are permanent damage that can only be rectified by replacing the tube (expensive, even on cheap scopes).

Probes

No scope is of much use unless it can be connected to the circuit to be tested, and a piece of leftover mains cable will not do! The reason for this is that the world is full of electro-magnetic waves, produced by anything that uses electricity (including the scope itself), that are all too easily picked up by an unshielded cable. Nearly all scopes have socket inputs of the BNC type, and for the minimum requirements a scope lead may consist of about 2m of coaxial cable with a BNC plug at one end and a pair of small 'croc clips' at the other. Generally it is much better to use a proper oscilloscope probe. These are priced at around £15. Only two types are usually available to the hobbyist, the X1 and X10 multiplier probes, sometimes combined in one unit with a switch. A X1 probe has no effect on the input signal, and only serves to match the impedance of the scope to that of the circuit under test in such a way as to minimise distortion of the signal. A X10 probe is used for the same purpose, but also increases the input impedance of the scope, typically from 1M to 10M Ω. This is of use where the signal to be displayed comes from a high impedance source, i.e. very little current can be drawn without affecting the signal being studied. These probes also reduce the effective capacitance applied to the circuit, which is of greater value when higher frequencies are being used. The disadvantage of the X10 probe is that the signal into the scope is reduced by a factor of 10, hence any measurement of voltage will be 10 times too small, and must be multiplied by 10 to give a correct result. Other probes the reader may come across are 'active probes', which are to produce a very high input impedance, and 'current probes', which, when placed around a wire, produce a voltage output proportional to the current flowing in the wire. Under no circumstances should an oscilloscope be connected to a voltage greater than the maximum indicated by the manufacturer, or serious damage may occur.

Another common mistake is to connect the 'ground' of the probe lead to a point which is not at ground potential. For safety, the scope is connected to the mains ground, but it is not always true that the chassis of the equipment being tested is also grounded. Look at the circuit and make sure that you choose an earth point at earth potential, or current will flow in the earth conductor and probably blow a fuse, or worse!

Usage

Now that you have some idea of how a scope works, what can you use it for? DC voltage measurement is just a case of grounding the input, selecting DC coupling, setting the V/cm control to a suitable value, and positioning the trace on one of the grid lines. Applying the probe to a point on a circuit will give a deflection which can be interpreted as a voltage using the scale (remember to connect the ground lead to zero or ground potential). If an AC voltage is present the waveform can be seen, and its peak-to-peak value obtained. This is the voltage from the top to the bottom of the waveform. Most volt-meters are calibrated in RMS (root mean square) volts, and so if an RMS reading is wanted it must be converted. For a sinusoidal voltage the RMS value is 0.707 times the peak value, which is in turn half the peak-to-peak value e.g. a waveform of peak-to-peak value 10V has a peak value of 5V and an RMS value of 3.535V. Most scopes have a switch which allows the input to be either AC or DC coupled. When in the DC position both DC and AC voltage can be measured, but if there is only a small AC voltage with a comparatively large DC (as with ripple on a DC supply) it may be difficult to measure the AC component. By switching to AC coupling the DC can be removed and the AC can be easily measured.

As the X axis is calibrated in time, it is just as easy to measure the period, and hence the frequency, of a waveform. Once a stable display is obtained, using the trigger con-

continued on page 53

FOUR SIMPLE CIRCUITS

To follow on from his popular series Starting Point, Robert Penfold has produced some simple but useful circuits for the inexperienced constructor to try his or her hand at. We show veroboard layouts, circuit diagrams and parts lists — the rest is up to you. All you have to do is follow the instructions.

Portable Stereo Amplifier

This amplifier is battery powered and is built into a case about 500mm wide which also houses the two loudspeakers. It is intended for use with a personal stereo cassette player, radio, or radio/cassette unit, and it enables loudspeaker operation to be obtained without losing portability. In effect it converts a personal stereo unit into a conventional stereo radio or cassette unit, but when maximum portability is needed the personal stereo unit alone can be used.

The circuit is based on a LM377N dual audio power amplifier device, and the two power amplifiers in this device are rather like operational amplifiers having high current output stages. The amplifiers are used in the non-inverting mode with the non-inverting outputs biased to an internal potential divider circuit of the LM377N which has its output at pin 1. C9 provides decoupling of this bias voltage. The negative feedback loops give the amplifiers a voltage gain of only about 15dB (5.5 times), and a higher level of voltage gain would be pointless since personal stereo units provide a fairly high output voltage of about 1 volt RMS. Using a 12 volt supply (eight 1.5 volt dry cells or preferably ten AA NiCad cells) the circuit provides a maximum output power of about 1 watt RMS or so (per channel) at low distortion. The volume, balance, and tone are adjusted using the controls on the personal stereo unit.

When S2 is open R7 results in the two output signals being mixed together to a certain extent, but they are mixed in such a way that signals in both channels tend to partially cancel out one another, and this boosts the channel separation. With the limited loudspeaker separation of the unit this can produce a better stereo effect, but how well or otherwise this system works depends to a large extent on the programme source used. However, in most cases it seems to give a more spacious and realistic effect.

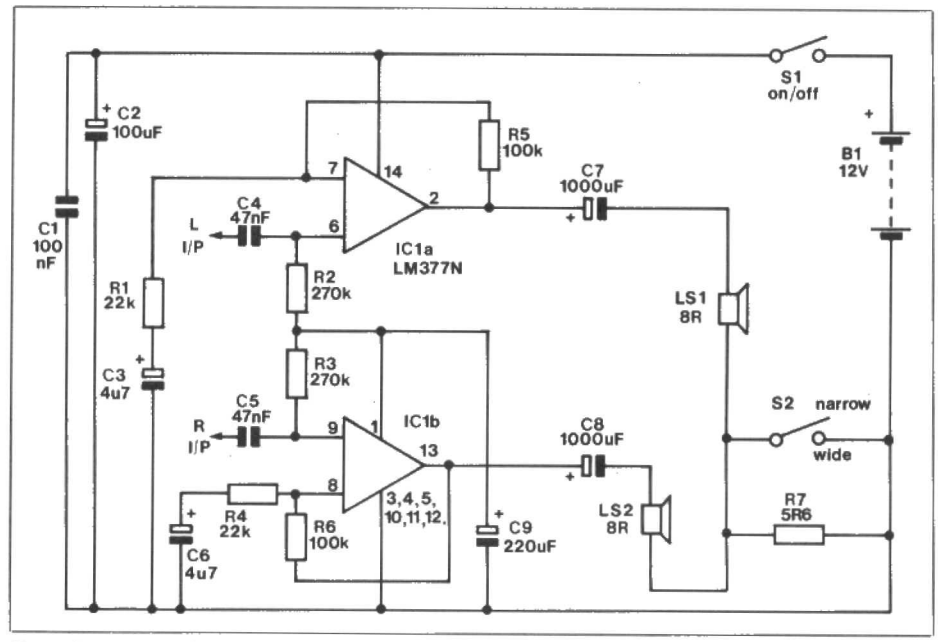


Figure 1. The portable stereo amplifier circuit diagram.

THE PORTABLE AMPLIFIER VEROBOARD ASSY PARTS LIST

Resistors — All 0.4W metal film 1%			
R1,4	22k	2 off	(M22K)
R2,3	270k	2 off	(M270K)
R5,6	100k	2 off	(M100K)
R7	5R6		(M5R6)
Capacitors			
C1	100nF polycarbonate		(WW41U)
C2	100uF 25V axial electrolytic		(FB49D)
C3,6	4u7 63V axial electrolytic	2 off	(FB18U)
C4,5	47nF polycarbonate	2 off	(WW37S)
C7,8	1000uF 16V	2 off	(FB82D)
C9	220uF 16V axial electrolytic		(FB61R)
Semiconductors			
IC1	LM377N		(QH38R)
Miscellaneous			
S1,2	SPDT sub-min toggle A	2 off	(FH00A)
LS1,2	Loudspeaker 6" x 4" 8R impedance	2 off	(WF50E)
B1	12V battery		
	Veroboard holes strips 0.1 inch matrix		
	Plastic or metal case		
	Connection wire as req.		(BL09K)

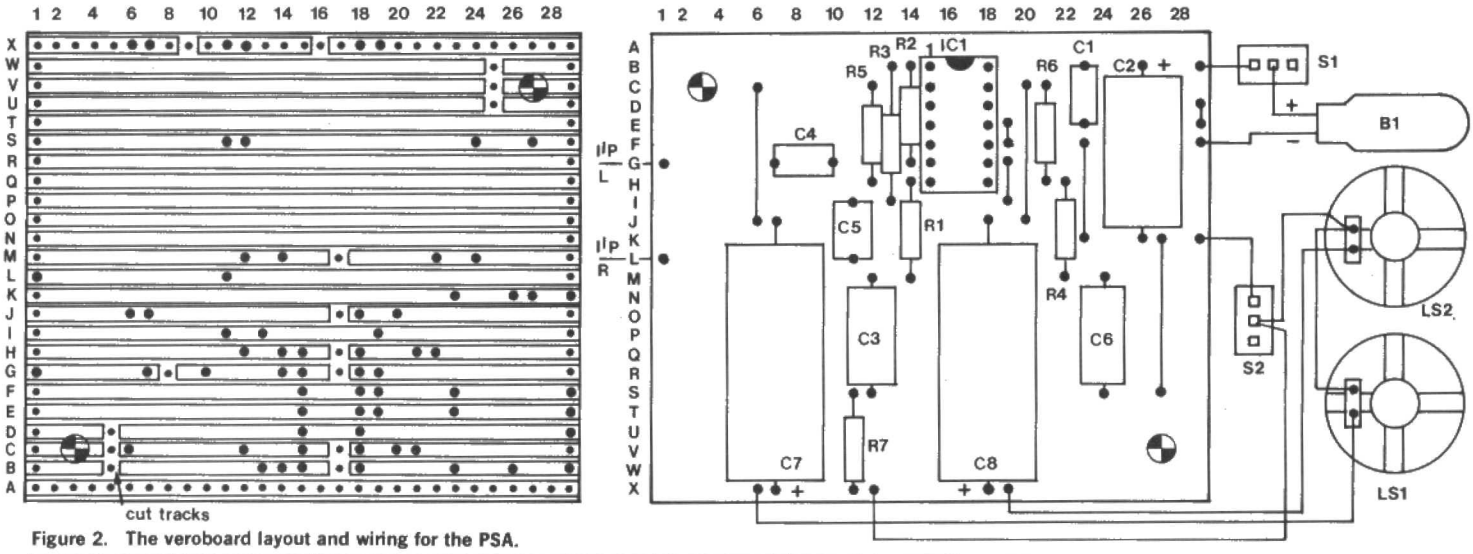


Figure 2. The veroboard layout and wiring for the PSA.

Sinewave Generator

Most Wien Bridge sinewave generator circuits use an expensive thermistor to stabilise the output signal level so that low distortion and no significant change in output amplitude with variations in output frequency are produced. This circuit uses an alternative approach with an automatic gain control circuit based on an operational transconductance amplifier being used to provide the output stabilisation. The noise and distortion performance is not equal to the best thermistor stabilised circuits, but at well under 1% it is more than adequate for most purposes including accurate frequency response measurements. There is no significant variation in the output level over the frequency range of the unit, which is approximately 15Hz to 150kHz in four ranges (15Hz to 150Hz, 150Hz to 1.5kHz, 1.5Hz to 15kHz, and 15kHz to 150kHz).

Normally circuits of this type use an operational amplifier with a controlled amount of negative feedback to maintain the voltage gain at the correct level,

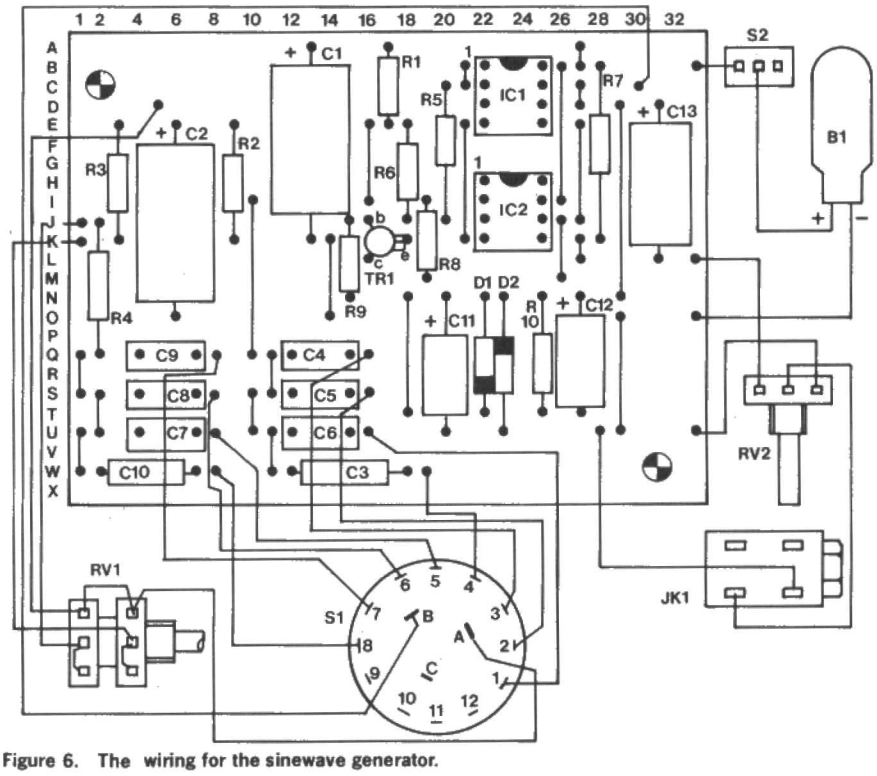


Figure 6. The wiring for the sinewave generator.

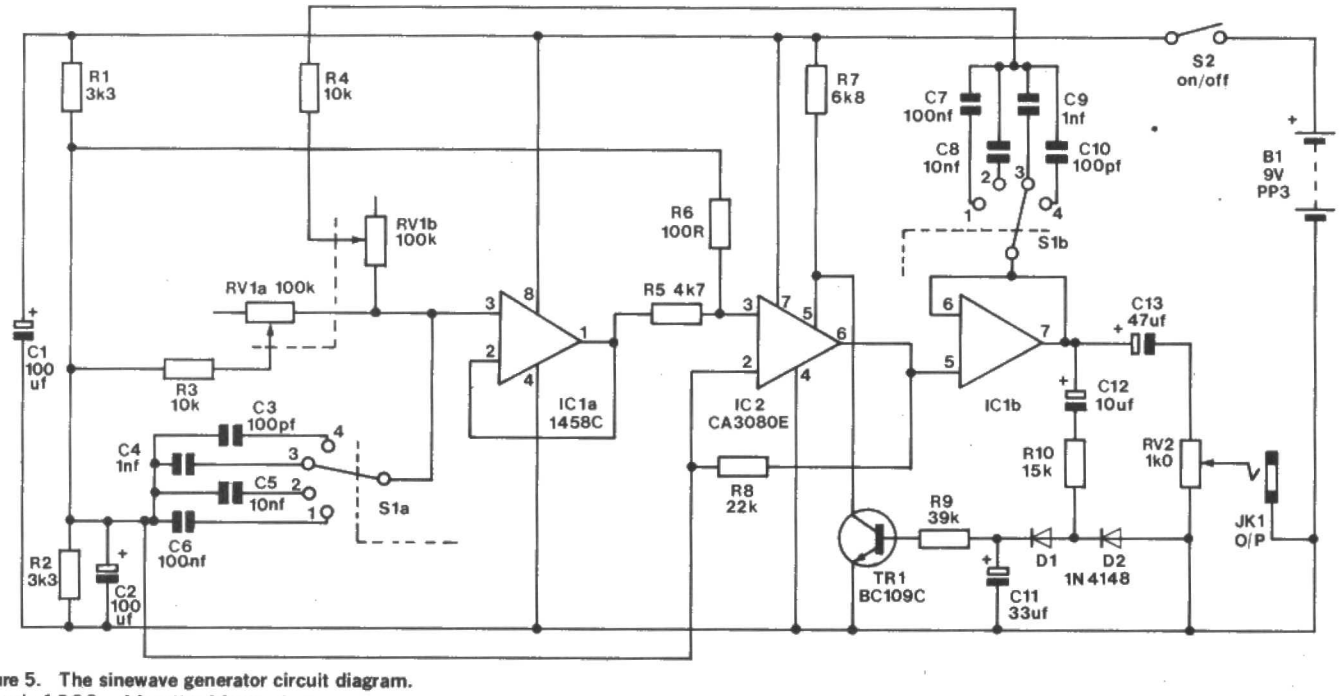


Figure 5. The sinewave generator circuit diagram.

THE SINEWAVE GENERATOR VEROBOARD ASSY PARTS LIST

Resistors — All 0.4W metal film 1%

R1,2	3k3	2 off	(M3K3)
R3,4	10k	2 off	(M10K)
R5	4k7		(M4K7)
R6	100R		(M100R)
R7	6k8		(M6K8)
R8	22k		(M22K)
R9	39k		(M39K)
R10	15k		(M15K)
RV1	100k dual pot lin		(FW88V)
RV2	1k0 pot lin		(FW00A)

Capacitors

C1,2	100uF 25V axial electrolytic	2 off	(FB49D)
C3,10	100pF 1% polysty	2 off	(BX46A)
C4,9	1nF polycarbonate	2 off	(WW22Y)
C5,8	10nF polycarbonate	2 off	(WW29G)
C6,7	100nF polycarbonate	2 off	(WW41U)
C11	33uF 16V axial electrolytic		(FB35Q)
C12	10uF 25V axial electrolytic		(FB22Y)
C13	47uF 25V axial electrolytic		(FB39N)

Semiconductors

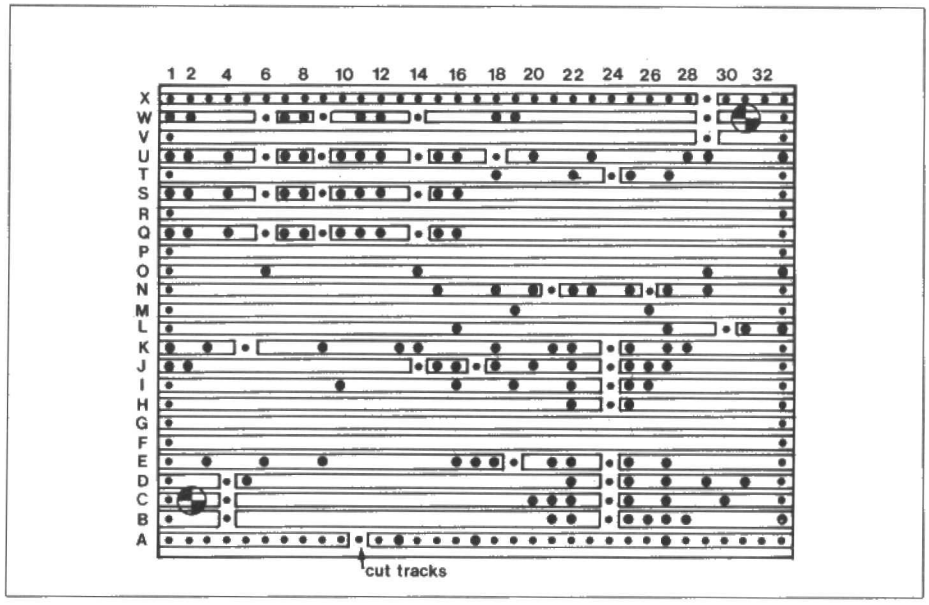
D1,2	1N4148	2 off	(QL80B)
TR1	BC109C		(QB33L)
IC1	1458C		(QH46A)
IC2	CA3080E		(YH58N)

Miscellaneous

S1	3-pole 4-way rotary Sw 4B		(FF75S)
S2	SPST sub-min toggle A		(FH00A)
JK1	Jack socket mono plastic		(HF90X)
B1	PP3 battery		
	PP3 connector		(HF28F)
	Veroboard holes strips		
	0.1 inch matrix		
	Plastic or metal case		
	Connection wire as req.		(BL09K)
	Knob	3 off	

but in this case a current controlled amplifier based on a CA3080E transconductance amplifier (IC2) is used. IC1 is used to provide buffering at the input and output of the amplifier so that it has a high input impedance and a low output impedance. R7 provides a strong bias to the amplifier input (pin 5) of IC2 so that the circuit has a high voltage gain and initially produces a high output level of low purity. Some of the output signal is coupled by C12 to a rectifier and smoothing circuit which generates a positive bias which switches on TR1. This diverts some of the bias current from the amplifier bias input of IC2, and by a simple feedback action stabilises the output level of the circuit at approximately 2 volts peak to peak. RV1 enables the output level to be adjusted from this maximum figure down to zero.

The current consumption of the circuit is about 4.5 milliamps.



Veroboard layout.

Headphone Enhancer

When headphones are used with an ordinary stereo (non-binaural) programme source proper stereo imaging is not obtained. The stereo image when using loudspeakers stretches from one loudspeaker to the other producing a sound-stage in front of the listener, but when using headphones the sound-stage is from one earphone to the other and therefore within the listener's head! This obviously gives far from realistic results, and the effect can be a little disturbing.

There are ways of obtaining a more spacious effect, and the most simple of these is to reverse the phase of one channel so that the two channels are out of phase and fail to produce a stereo image. With this method sounds tend not to have any definite apparent origin,

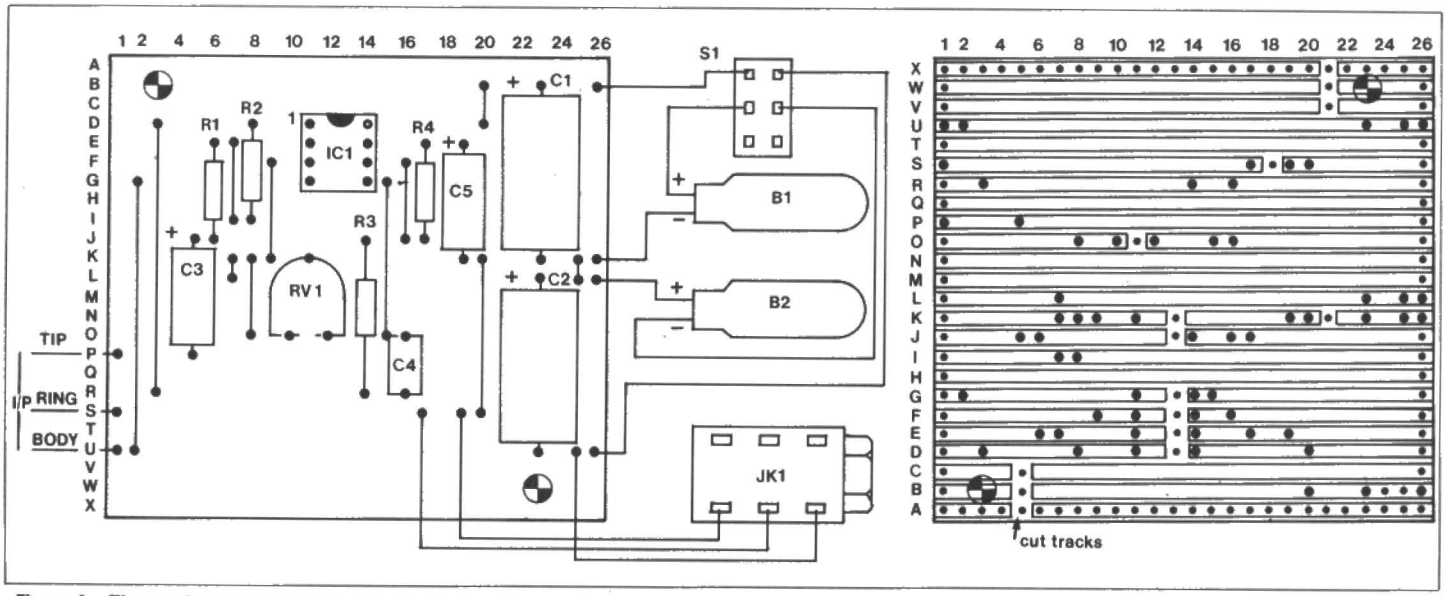

1 2 4 6 8 10 12 14 16 18 20 22 24 26
A B C D E F G H I J K L M N O P Q R S T U V W X
R1
R2
IC1
R4
C1
S1
C5
B1
C3
R3
C2
B2
RV1
C4
TIP
RING
BODY
JK1
1 2 4 6 8 10 12 14 16 18 20 22 24 26
X W V U T S R Q P O N M L K J I H G F E D C B A
cut tracks

Figure 4. The veroboard layout and wiring for the headphone enhancer.

but have a vagueness in this respect. A better effect is produced using a compromise between normal stereo and out of phase stereo, with the two channels in phase at some frequencies and out of phase at others. This gives a more vague and spacious effect than normal stereo, but does not totally destroy the stereo imaging.

The circuit shown here is a simple phase shift circuit which can be used as a headphone enhancer. IC1a is a straightforward inverter, and IC1b is used as a conventional phase shifter. At low frequencies C4 has no significant effect and IC1b acts as an inverter so that there is no phase shift through the circuit as a whole. At higher frequencies the coupling to the non-inverting input through C4 reduces the phase shift provided by the circuit. This gives zero phase shift at the highest audio frequencies, and a 180 degree phase shift through the circuit as a whole. R5 is used to control the point at which the transition from zero phase shift to 180 degree phase shift commences, and with this component at minimum the circuit gives no significant phase shift at audio frequencies (i.e. normal stereo). At maximum value a large phase shift is produced over much of the audio spectrum. In practice this component is set to give the best subjective results.

The enhancer can be used in either stereo channel, and the output will drive low, medium, or high impedance headphones satisfactorily.

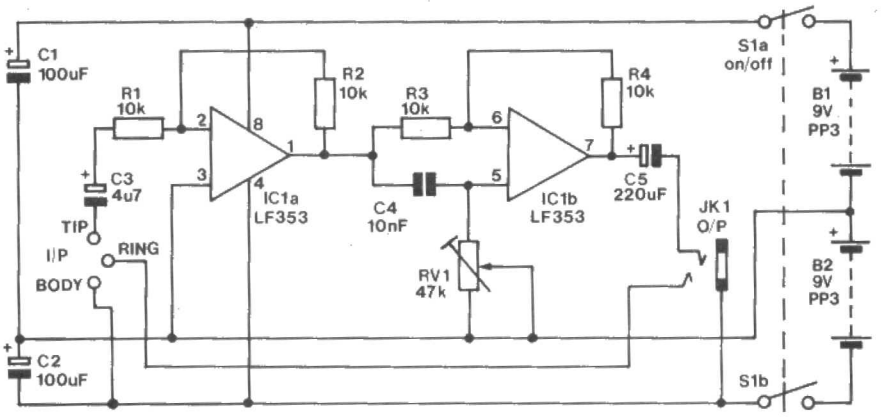


Figure 3. The headphone enhancer circuit diagram.

THE HEADPHONE ENHANCER VEROBOARD ASSY PARTS LIST

Resistors — All 0.4W metal film 1%			
R1,2,3,4	10k	4 off	(M10K)
RV1	47k hor. s.min preset		(WR60Q)
Capacitors			
C1,2	100uF 25V axial electrolytic	2 off	(FB49D)
C3	4u7 63V axial electrolytic		(FB18U)
C4	10nF polycarbonate		(WW29G)
C5	220uF 16V axial electrolytic		(FB61R)
Semiconductors			
IC1	LF353		(WQ31J)
Miscellaneous			
S1	DPDT sub-min toggle E		(FH04E)
JK1	Jack skt std		(HF92A)
	Jack plug stereo plastic		(HF88V)
	Cable twin (as required)		(XR21X)
B1	PP3 battery	2 off	
	PP3 connector	2 off	(HF28F)
	Veroboard holes x strips		
	0.1 inch matrix		
	Plastic or metal case		
	Connection wire (as req.)		(BL09K)

Stylus Organ

Conventionally a stylus organ uses a simple oscillator in conjunction with low frequency amplitude or frequency modulation (tremolo or vibrato) to produce a more interesting and musical sound than that given by an unmodulated oscillator. This circuit uses an alternative approach and has two audio oscillators. One of these produces the main audio tone signal while the other is a few hertz off-tune and mixed with the main signal at about -10dB. This gives a much "richer" sound than using a single oscillator and in this respect the circuit is at least equal to conventional designs, if not superior.

The two oscillators each use a CMOS 4046BE device which is a low power phase locked loop, but only the voltage controlled oscillator section of each 4046BE is used in this circuit, plus the internal 5 volt zener diode of IC2 which gives a stabilised supply for the tone generators in conjunction with load resistor R4 and decoupling capacitor C1. A number of 100k preset resistors are used to provide a series of voltages which give the appropriate notes from the tone generator. Thirteen presets are

continued on page 63

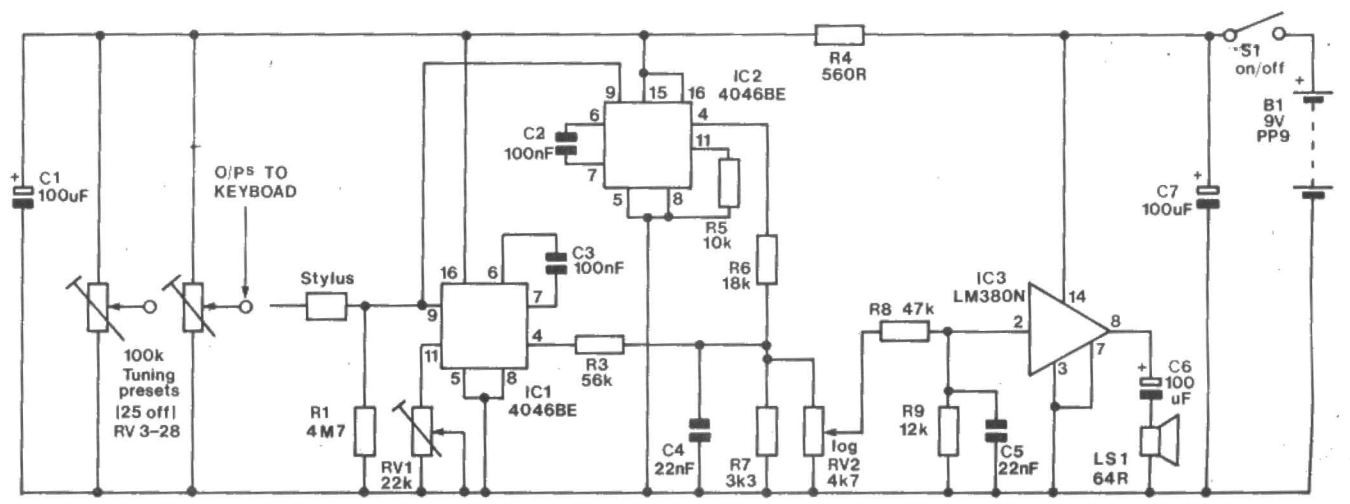


Figure 7. The stylus organ circuit diagram.

WORKING WITH OP-AMPS

Part 5 *by Graham Dixey C.Eng., M.I.E.R.E.*

The circuits which follow are mainly concerned with measurements. The ability to measure various quantities to a reasonable degree of accuracy is vital in electronics. Because of the nature of a signal or its source, amplification is often needed, either to raise the signal level to a value high enough to drive a moving-coil meter, for example, or to 'buffer' a high impedance source. In other instances an amplifier may be used in such a way as to 'linearise' the measurement of passive quantities such as resistance and capacitance, so improving scale readability and accuracy. These are all possible applications for the ubiquitous op-amp. Some of the circuits described point to possible applications of the op-amp in a particular role; others are complete instrument designs (albeit not very sophisticated) in themselves, ready to be engineered into useful tools for the work-bench. It is hoped that they are all of some interest.

Peak Signal Detector

Voltmeters for measuring a.c. are often 'mean-sensing, r.m.s. calibrated' for sine-wave inputs. Sometimes there is a need for a meter that will read peak values of any waveform, the peak signal detector can be used as the basis for such an instrument.

The circuit is shown in Figure 1 and employs two op-amps. One of these, IC1, is the peak detector proper while IC2 is used as a voltage follower to isolate the detector from the output. The function of the circuit is to develop and retain (temporarily) the peak value of an input voltage, whatever the waveform of that input. As shown, the circuit responds only to positive peaks because of the polarity of diode D1. If this diode is reversed then the circuit will respond to the negative peaks instead. Of course, if the input waveform is symmetrical it hardly mattters which peak is being measured since both are the same. However, for asymmetric waveforms it may be useful to be able to measure either peak value at will or even total peak to peak value.

Now for the operation of the circuit. If it is assumed that the capacitor C1 is initially uncharged (perhaps after re-setting with switch S1) then only if diode D1 conducts can C1 acquire any charge. This will be achieved for any positive input, no matter how small, since the high gain of the op-amp will ensure that D1 is forward-biased. To appreciate the scale of this statement, assume that the diode needs 0.6V of forward bias and the op-amp gain is 10^5. Then the peak input signal to cause the diode to conduct (just) is $0.6/10^5=6$ microvolts. Thus, the circuit is capable of responding to very small signal levels though it will undoubtedly need some gain later to make use of it, even assuming that 'noise' doesn't get into the act. An essential feature of the circuit is that it remembers the largest peak applied to it; the voltage developed across C1 only changes upward, never downward (except that the charge on C1 decays slowly once the input level has been reduced). Thus, if three successive positive peaks, of values 1V, 3V and 2V are applied to the circuit, it will store the 3V peak and disregard the later 2V peak. This happens because whenever the input voltage is less than the capacitor voltage, the diode becomes reverse-biased and there is only the input impedance of the op-amp as the discharge path for C1. To answer the question, 'when does the capacitor stop charging up?', the answer is that it does so when the voltage at the inverting input equals that at the non-inverting input.

Figure 2 shows the ideas of Figure 1 extended to measure peak to peak values of any waveform. IC1 and IC2 respectively measure the positive and negative peaks of the input waveform. These peak values, V_{p1} and V_{p2} may or may not be equal. The total peak to peak excursion is $V_{p1} + V_{p2} = V_{pt}$. This 'total' voltage is developed by using a 'subtractor' circuit, based on IC3. This works because the output of IC3 is the difference between its two inputs which are of opposite sign anyway. Thus, $V_{pt} = V_{p1} - (-V_{p2})$.

$= V_{p1} + V_{p2}$

The Linear Rectifier

This circuit, shown in half-wave form in Figure 3, uses the high gain of the op-amp to 'linearise' the conduction of a rectifier diode. As is well known, a silicon diode needs about 0.6V in the forward direction before conduction commences; which means, of course, that at low signal levels the d.c. output may be negligible or zero. Linearising the operation means that the rectifier output is made to be directly proportional to the signal input, whatever its size. Characteristics for normal and linear operation are also shown in Figure 3.

The circuit acts as an inverter, the point being that the feedback loop is only completed when one or other diode conducts. Up to this point the op-amp operates at full open-loop gain. This means that if the open-loop gain is, say, 10^5 then the input required to start a diode conducting is about 6 microvolts. Once a diode is conducting the gain is unity since it is then defined by either R2/R1 (negative half-cycles) or R3/R1 (positive half-cycles), the usual expression for the gain of an inverter. Two outputs are available, either positive or negative going. The circuit does not have to be used at unity gain. For example, if R2 and R3 are both increased to 100kΩ, the gain is slightly less than five.

If a full-wave rectifier is required, the circuit of Figure 4 can be used. The two separate outputs of the original circuit are each given unity gain by a second op-amp IC2 and, at the same time, the negative half-cycles are inverted to give a full-wave output.

High Impedance d.c. Voltmeter

A limitation of moving-coil multimeters is their low terminal impedance for small voltages. For example, if a typical sensitivity of 20kΩ/V is considered when the voltmeter is on the 3V range, then the impedance that the meter presents to the test circuit is only 20 × 3 = 60kΩ, which may not always be

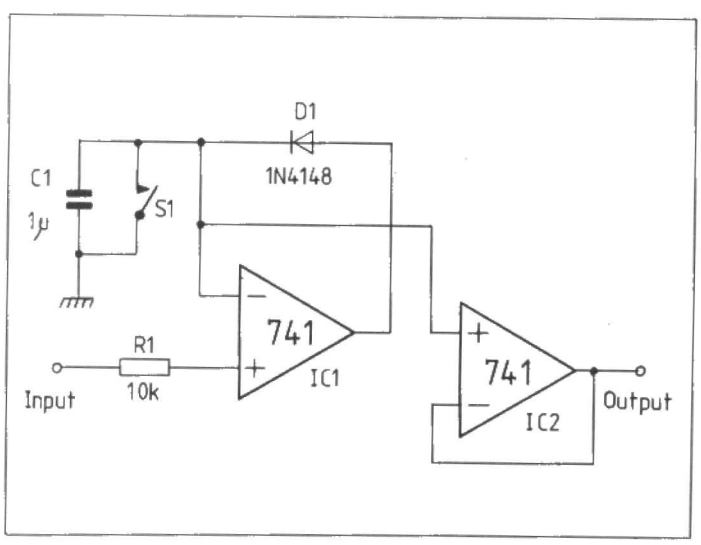


Figure 1. Peak Voltage Detector

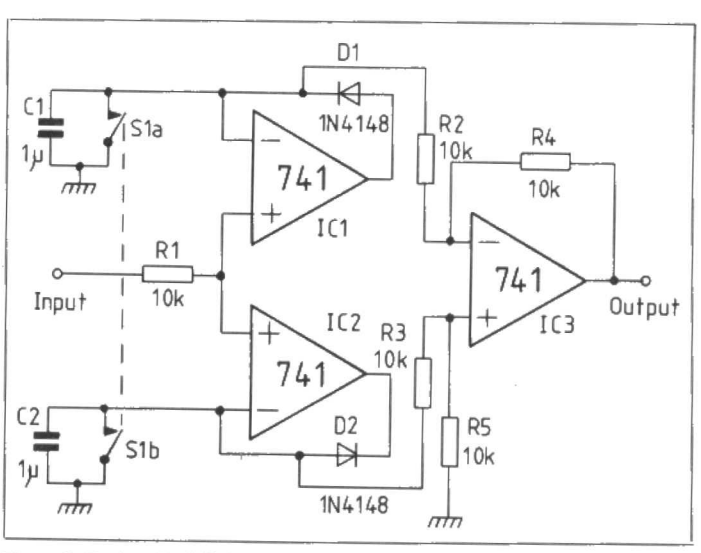


Figure 2. Peak to Peak Voltage Detector.

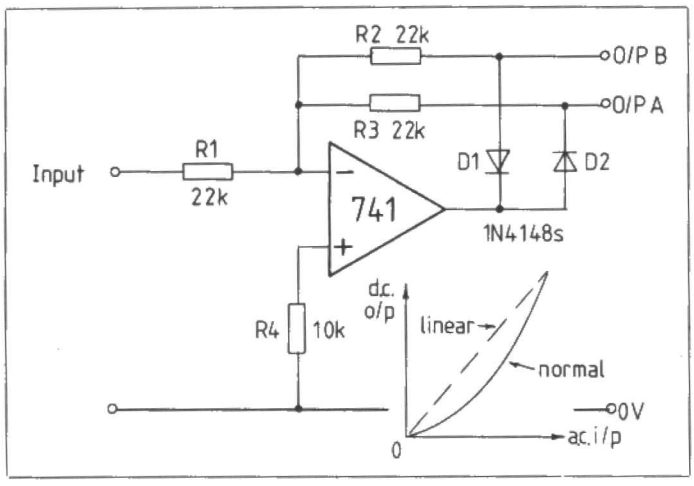


Figure 3. Linear Rectifier (Half-wave)

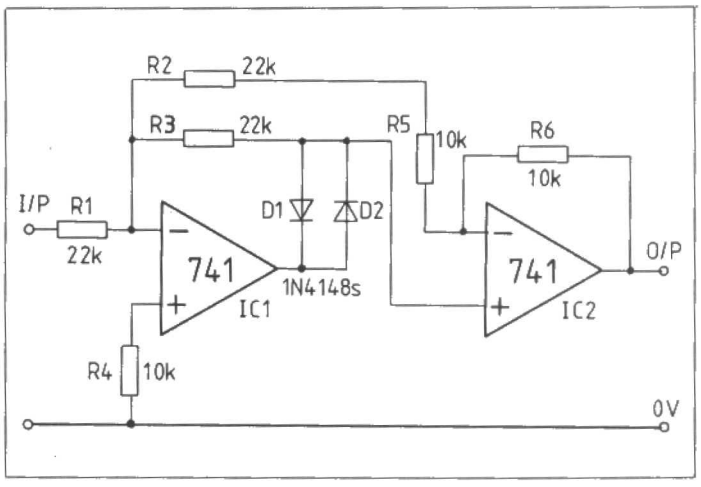


Figure 4. Linear Rectifier (Full-wave)

high enough. This is because the lack of any amplification means that the meter has to draw all of its current from the test circuit. Using the op-amp allows gain to be interposed between the test point and the meter. Hence, two advantages accrue; the input impedance is increased and smaller voltages can be measured with an accuracy not possible with conventional multimeters.

There are a variety of ways of achieving these aims and Figure 5 shows an approach based on the use of an op-amp in the non-inverting mode. The gain is determined by R8, RV2 and R9 and is set at 200 by these values. Since this gain is only required at the lowest full-scale input value (100mV), an input attenuator is used (R1-R6) to reduce the input level on other ranges. Any of the full-scale inputs will give 10V d.c. at the output of the op-amp thus, if using a 1mA meter, R7 and R10, together with the resistance of the meter should equal 10kΩ. The arrangement is not critical since RV2 is used to make slight gain adjustments i.e. is used to calibrate the instrument.

The result is an instrument that will measure direct voltages down to a few millivolts at an input impedance always better than 100kΩ.

A Linear Ohmmeter

The measurement of resistance is usually carried out in one of two ways, either with a bridge or, more likely, using the resistance facility of a multimeter. A bridge that is of any real use is likely to be expensive so that the amateur (and many professionals) resort to the multimeter to sort out the values of unknown resistors. Unfortunately, because of the basic principle on which it works — deflection being inversely proportional to resistance — the scale is decidely non-linear. This is acceptable for rough and ready checks but rules out measurements of any precision. Once again the op-amp comes to the rescue; since the gain of an inverting amplifier is directly proportional to the value of its feedback resistor then, for a constant and precise input, the output is directly dependent upon the value of this feedback resistor. By making the unknown resistance act as the feedback resistor, the output obtained, indicated on a moving-coil meter, directly relates to the unknown resistance. The idea can be extended to measure different ranges of resistance by switching in different values of input resistor. The circuit is shown in Figure 6.

The part of the circuit centred on transistor Q1 provides a stable standard voltage — in this case 1V. This is adjusted precisely by means of RV1 when a voltmeter is connected between its wiper and 0V to set up this standard value. This stabilised voltage is the constant input to the inverting amplifier. The input resistors are R3-R6 and their values are equal to the full-scale resistance value of the range selected. Thus, as shown, there are four ranges, selected in decades, from 1kΩ to 1MΩ full-scale. Obviously alternative values could be used although those shown are probably as useful as any. A pair of terminals is provided for the unknown resistor Rx and these are shunted by a 1kΩ resistor R8 in series with a normally closed push-button switch. Some arrangement like this is necessary to protect the meter because, if the Rx terminals are open while power is applied to the circuit, the amplifier will then have its full open-loop gain with the result that the output will go into negative saturation. The result would be that the meter pointer would endeavour to wrap itself around the end stop. With R8 equal to 1kΩ, the gain can never exceed unity when S2 is closed. Pressing S2 replaces the 1kΩ resistor with Rx and the meter will read its value. Similar reasoning

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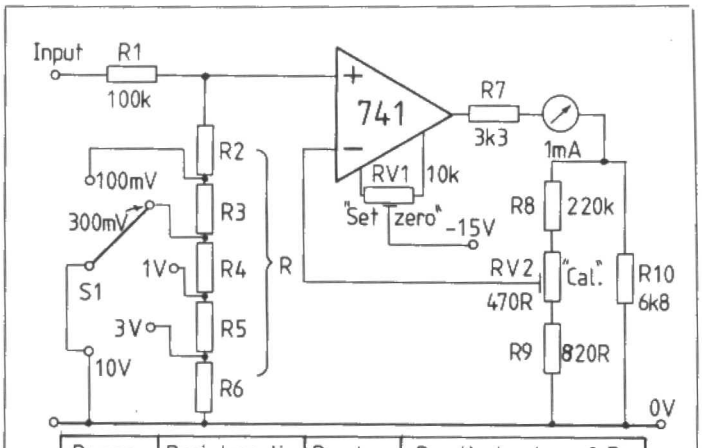


Range	Resistor ratio	R value	Practical value of R
100mV	2 : 1	100k	100k
300mV	6 : 1	20k	18 + 2.2 = 20.2k
1V	20 : 1	5.26k	4.7 + 0.56 = 5.26k
3V	60 : 1	1.69k	1 + 0.68 = 1.68k
10V	200 : 1	500R	220 + 270 = 490R

Figure 5. High Impedance d.c. Voltmeter

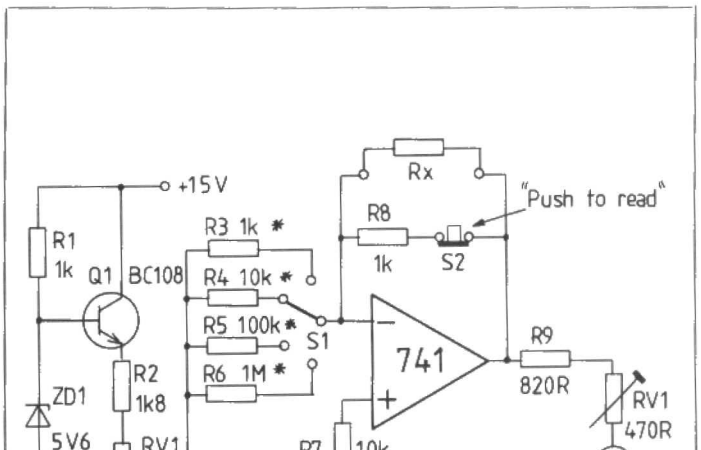
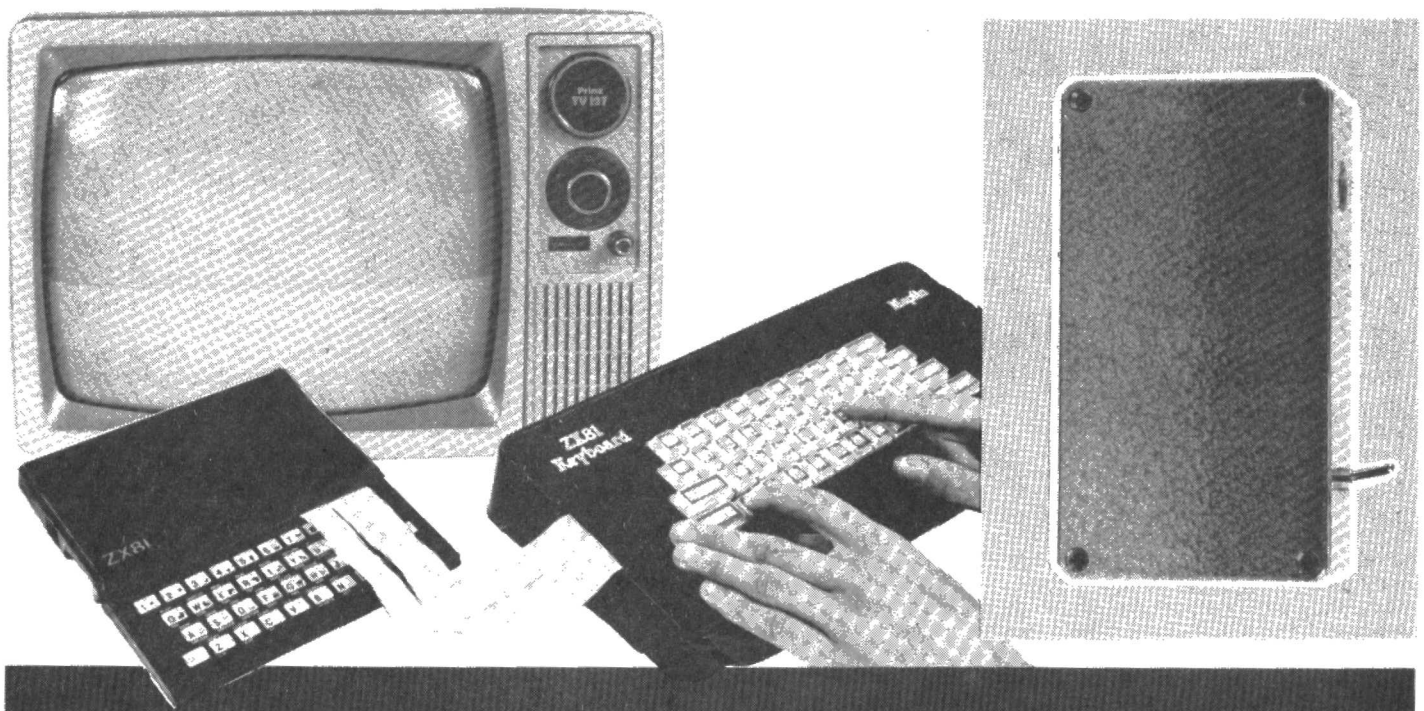


Figure 6. Linear scale Ohmmeter

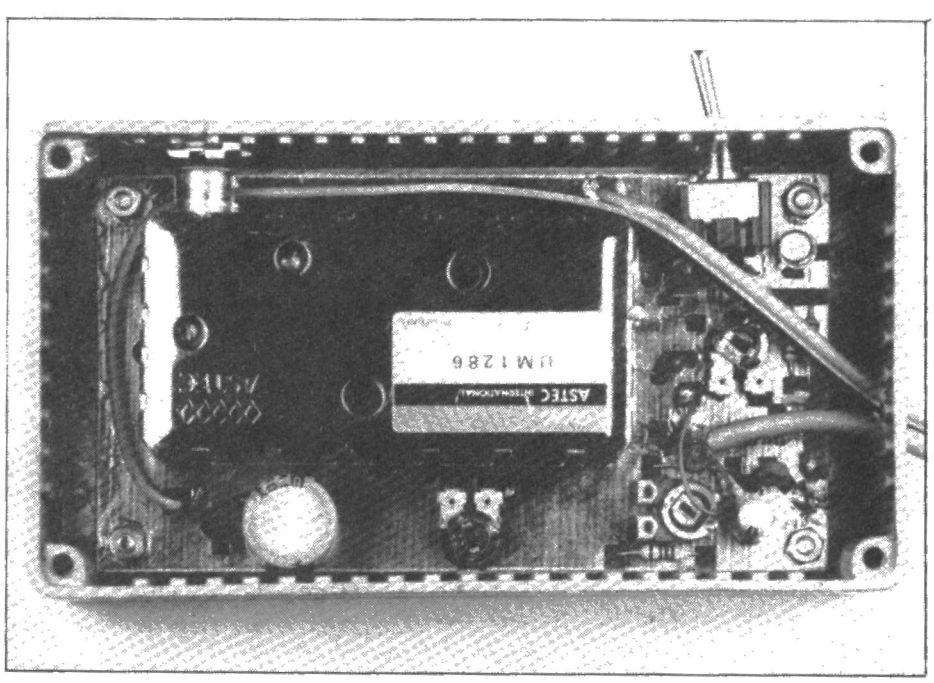


ZX81 TV SOUND AND NORMAL-INVERSE VIDEO

by Dave Goodman

- **Audio input for sound on TV speaker**
- **Video reversing switch for normal or inverted display**
- **Can be used with our sound generator or voice synthesis modules**

Sound effects, whether they are taped voice for narration purposes or 'laser blasters' and 'photon zappers', will give an added degree of reality to computer programs. This is especially true for the ZX81, with its low resolution Graphics mode and Plotting displays, but unfortunately facilities for audio signal processing have not been included as part of the system hardware, and must be fitted externally.



Circuit Description

The heart of the system is MODULATOR 1, which produces a 591.5 MHz vision carrier. This is used to drive a UHF TV set (either monochrome or colour), but will only produce a black and white picture.

All necessary video modulation signals, along with frame and sync pulses, are produced within the ZX81 circuitry. Figure 4 shows the basic waveform connected to pin 4 (the video input).

An externally produced audio signal

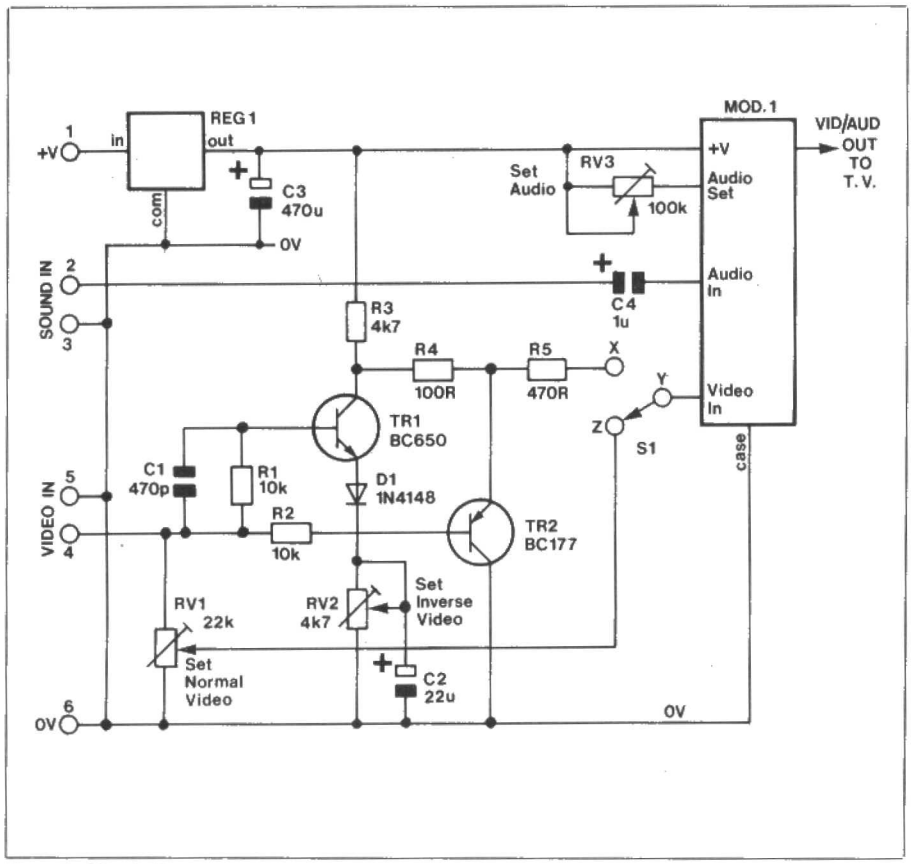


Figure 1. Circuit diagram

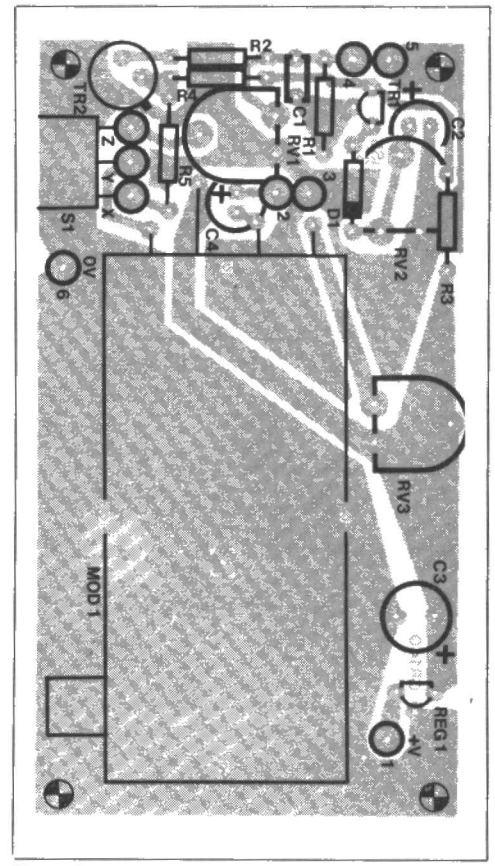


Figure 2. PCB and legend

is connected to pin 2, via C4, to MOD 1, and this is used to frequency modulate a 6 MHz sound carrier that is generated internally. Both video and sound sub-carriers are then added to the vision carrier, and the input to the TV set is via the aerial socket. RV3 can be adjusted to 'tune' the audio signal carrier if required, and RV1 can be set to give the desired contrast level on the TV display (see setting up details).

To achieve a satisfactory sound output from the TV speaker a minimum of 100mV peak input level is needed, but signals in excess of 1V peak may produce distortion, and will need to be attenuated with a suitable resistor. Note that Maplin sound modules develop the correct signal levels, and will not need adjusting.

REG 1 has been added so that the positive rail (pin 1) can be connected to a separate PSU or to the ZX81 PSU direct, with a dual 3.5mm connector. This saves taking the computer +5V rail into the outside world with possible disastrous consequences.

As an extra facility to this project, circuitry has been added to invert the produced display, for white printing on a black background. This effect can be invaluable if eyestrain is to be prevented when using the computer for long periods. To produce this effect it is necessary to invert the video waveform before connecting into MOD 1, but if the composite signal is inverted, the frame and sync pulses will be also, and the picture will be lost. The waveform in figure 4 shows the correct levels for operation and TR1 inverts both video and sync signals. RV2 sets the conduction point of TR1 so that the peak black and white signals can be adjusted for definition. TR2 conducts to the negative sync. pulse, and pulls the potential set at R4 and R5 down to 0V, keeping the sync pulse negative but allowing the video to remain inverted. S1 selects either inverted or normal video, so that preprogrammed cassettes can be used without problems. Note that no facility exists for driving a monitor screen, although the video in, from S1, could be connected by an emitter follower for this use, but this would be a matter for further experimentation.

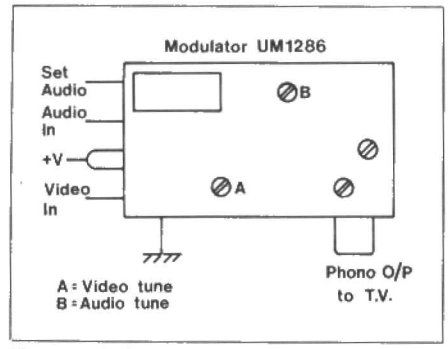


Figure 3. Modulator pin-outs

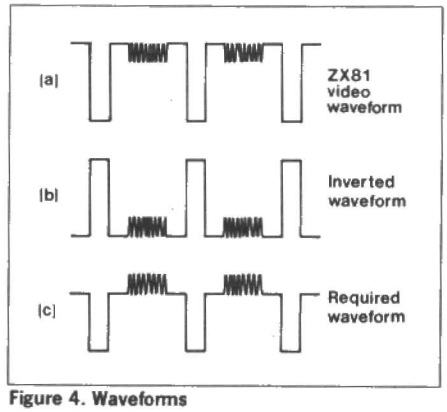


Figure 4. Waveforms

Construction

Building the project is quite straightforward. Ensure that the 0V pins 3 to 5 and 6 are soldered to both sides of the PCB 0V (earth plane). MODULATOR 1 has four legs, which go through the PCB and solder onto the track underneath. Make sure that REG 1, TR1, and TR2 have been inserted the right way round (see legend), and that D1, C2, C3 and C4 are correctly orientated.

When soldering make sure that no shorts exist between tracks on both sides of the PCB. Clean any excess solder from the PCB before use.

Assembly and Setting Up

I must stress here that extreme caution should be exercised when soldering to the ZX81. It is very easy to damage the computer by faulty workmanship, and any manufacturing guarantees will probably be forfeit if this happens, so follow all the instructions carefully.

For all adjustments to pots and dust cores it is advisable to use a plastic trimming tool, as this will eliminate the possibility of damage occurring from breakages.

Set the wipers of RV1, RV2 and RV3 to central positions, then refer to figure 5 connection diagrams. Remove the ZX81 PCB from its case and snip the centre wire coming from the UM1233 modulator halfway between it and the PCB. Take a piece of connecting CO-AX cable, strip both ends about 15mm down and separate the mesh screen from the inner conductor. Twist, tin, and solder the screen to the outside

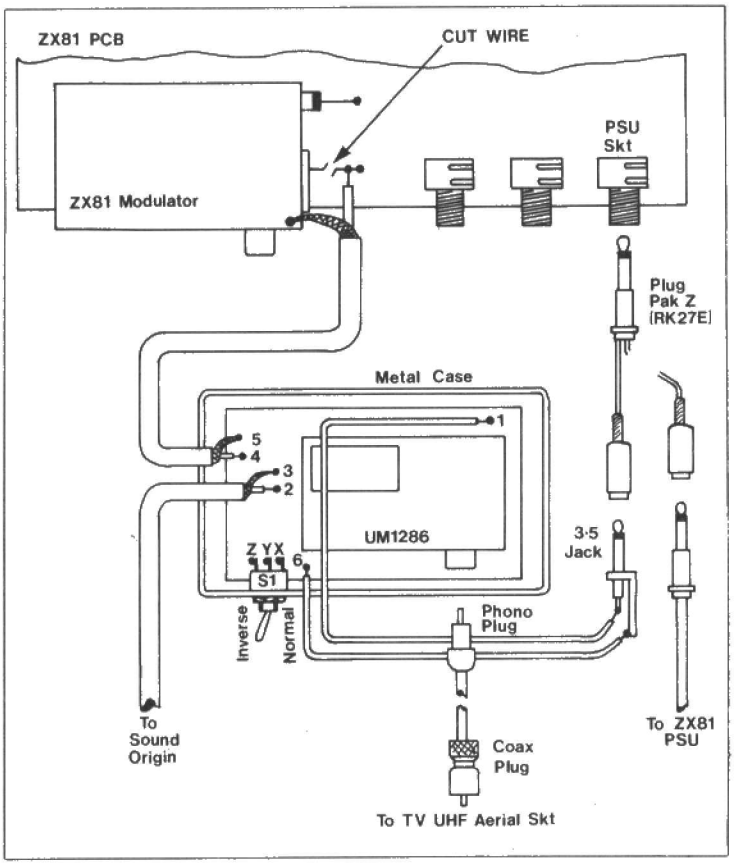


Figure 5. Connections to the ZX81 and TV

PARTS LIST FOR ZX81 TV SOUND/ INVERSE VIDEO

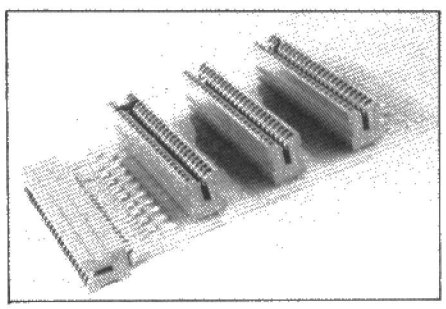
Resistors — All 0.4W 1% Metal Film

R1,2	10k	2 off	(M10K)
R3	4k7		(M4K7)
R4	100R		(M100R)
R5	470R		(M470R)
RV1	22k Hor sub-min Preset		(WR59P)
RV2	4k7 Hor sub-min Preset		(WR57M)
RV3	100k Hor sub-min Preset		(WR61R)
Capacitors			
C1	470pF ceramic		(WX64U)
C2	22uF 16V PC elect		(FF06G)
C3	470uF 16V PC elect		(FF15R)
C4	1uF 35V tantalum		(WW60Q)
Semiconductors			
D1	1N4148		(QL80B)
TR1	BC650		(QB74R)
TR2	BC177		(QB52G)
REG1	uA78L05AWC		(QL26D)
Miscellaneous			
MOD1	UM1286		(BK66W)
	Circuit Board		(GB14Q)
	Veropin 2141	1 Pkt	(FL21X)
	Box DCM5004		(LH71N)
	C/S screw 6BA × ½"	1 Pkt	(BF12N)
	Nut 6BA	1 Pkt	(BF18U)
	Washer 6BA	1 Pkt	(BF22Y)
	Spacer 6BA × ¼"	1 Pkt	(FW34M)
S1	Switch sub-min toggle A		(FH00A)
	Plug pak Z		(RK27E)
	Plug plas 3.5		(HF80B)

A complete kit of parts is available for this project.
Order As LK02C **Price £19.95**

edge of the ZX81 modulator case. The inner conductor is then soldered to the cut video input wire protruding from the PCB. The other end of the CO-AX cable goes to pin 4 and pin 5 (0V) on the sound module.

For the positive supply it is advisable to use Plugpak Z (RK27E) and a 3.5mm plug (HF80B) with the plug tip connecting to positive (pin 1). Supplies between +8V and +30V may be used here, so it can be safely connected to the ZX81 PSU using the recommended adaptor. Solder the plug sleeve to 0V (pin 6).



The ZX81 Extendiboard.

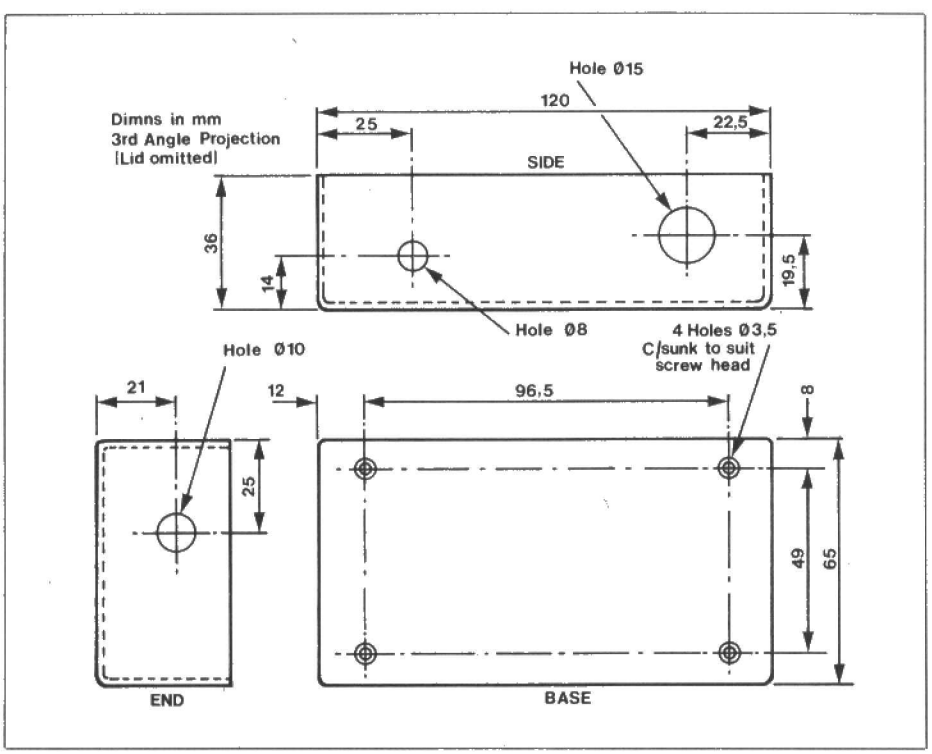


Figure 6. Box drilling details and dimensions

Your Sinclair PSU will then plug into the remaining socket on the plugpak, which then connects into the ZX81 power socket.

Fit a phono to CO-AX lead between the sound module and TV set, then switch on both PSU and TV. Tuning should be around channel 35. Position S1 to the 'NORM' mode and the 'K' cursor will appear as normal, but if the picture is grey or lacking contrast then adjust RV1.

Set S1 to the 'INV' mode and adjust RV2 for peak black background and minimum white streaking. Try entering a CHR$ SET print routine for full character display, then balance RV1 and RV2 in appropriate modes for picture clarity. Note that TV contrast and brightness may need to be adjusted when switching between modes.

Audio signals should be connected to pins 2 and 3 (0V) with screened cable. Approximately 100mV peak signal is required, although levels up to 1V peak may be acceptable. Apply a sound source, either a signal generator or a sound producing module if you possess one, to the audio input. Slight retuning of the TV may be necessary to balance sound and video reception. Switch between modes (S1) and ensure that sound is available on both settings.

Figure 3 shows the UM1286 MODULATOR and tuning cores. Although not advisable, slight adjustment of the two marked A and B can be made with a plastic trimming tool for improved sound and picture reception, but only do this if you feel there is real room for improvement. It is recommended that you fit this project into a box, and figure 6 shows drilling positions for the switches and sockets etc.

WITHIN YOUR SCOPE continued from page 43

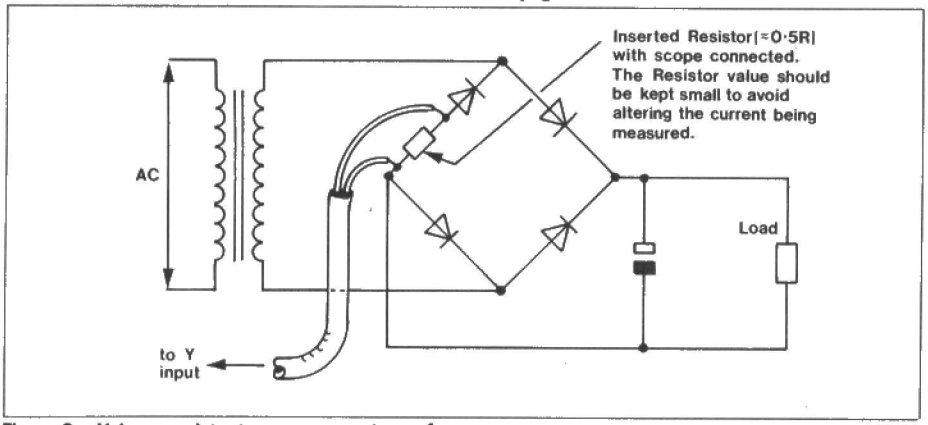

Inserted Resistor(≈0·5R) with scope connected. The Resistor value should be kept small to avoid altering the current being measured.
AC
Load
to Y input

Figure 3. Using a resistor to see a current waveform.

trols, the period can be measured as the time taken for a given point in a waveform to re-occur, e.g. if a waveform completes one cycle in one cm on the screen and the time/division selector is at 1ms per cm, then the period is one millisecond, and the frequency, given by the reciprocal of the period time, will be 1kHz.

Time and voltage measurement are the basic functions of an oscilloscope, but it is not difficult to use it for other purposes. If you need to see a current waveform, then a known resistor, small enough not to greatly affect the circuit under test, can be put into circuit, and the scope connected across the resistor. The voltage waveform on the screen will then be proportional to the current flowing in the resistor, as V=IR (see figure 3). A current probe uses a different principle, which does not affect the circuit, but these are very expensive, certainly much dearer than a resistor, and not widely available.

Another quantity of interest is phase. This can be seen on a scope by displaying the waveforms on a dual beam scope (preferably using chopped mode) and measuring the time displacement by direct comparison. An alternative can be used when there is an external X input and both waveforms are sinusoidal. The two signals are fed to the X and Y inputs, producing what is known as a Lissajou figure. This will be a diagonal straight line if the signals are in phase, but will appear elliptical if there is a phase difference. Figure 4 shows the display and how to obtain the phase angle value.

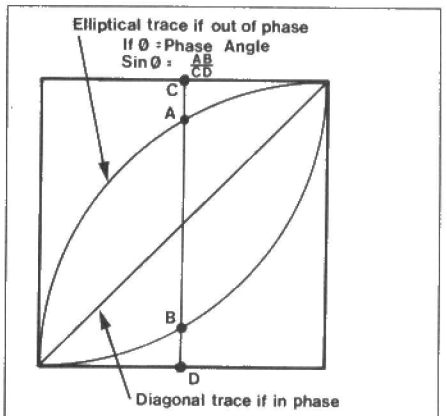

Elliptical trace if out of phase
If Ø = Phase Angle
Sin Ø = AB/CD
C
A
B
D
Diagonal trace if in phase
CD is the maximum height of the trace.
AB is the height of the ellipse at its centre.
For accuracy adjust gain for a large as possible display. The diagonal will be the other way if the signals are 180° out of phase.

Figure 4. Phase measurement using Lissajou figures.

Fault-Finding

To use a scope as a test or fault-finding instrument, it is of course necessary to know what waveform is to be expected of a given point in a circuit. This information can often be found in service manuals, but an understanding of how a circuit works is essential if a scope, or indeed any other instrument is to be used for fault-finding. Fortunately many of the circuits published in the hobbyist magazines have detailed descriptions of how each circuit works, and these can be of great help. Often it is possible to 'follow' a signal through a circuit from input to output, and see with a scope what each part of the system is doing. In this way each part is checked until an unexpected result appears, indicating a fault.

There are many books on the subject of fault-finding with a CRO, and they cover in greater detail than is possible here how to check different types of circuits. With experience you may be able to quickly find faults in the most complicated equipment with only a scope. As the cost of these useful instruments decreases, a scope is more and more representing a worthwhile investment to any serious electronics enthusiast, and will help him or her to a greater understanding of their hobby.

WORKING WITH OP-AMPS continued from page 49

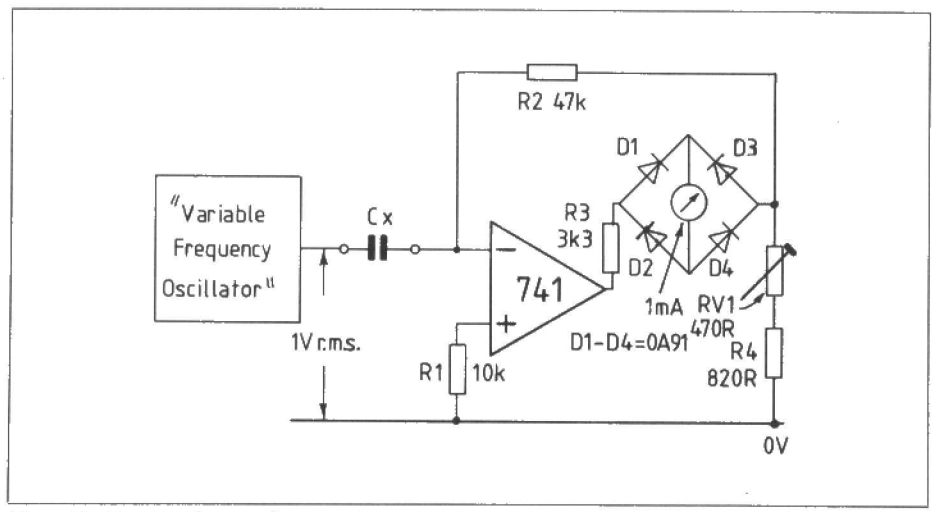


Figure 7. Linear-scale capacitance meter.

shows that, when the value of Rx is totally unknown, the highest resistance range should always be selected. To be absolutely safe,a circuit consisting of two germanium diodes in inverse parallel (e.g. 0A91s) can be wired across the meter. Resistor R9 and the pre-set RV2 determine the current in the meter, calibration being effected by means of RV2. This is done by selecting the 10kΩ range, using a close tolerance 10kΩ resistor for Rx (e.g. a decade box or 1% type) and adjusting RV2 for precisely full-scale deflection. This assumes that RV1 has been adjusted already to give exactly 1V at its wiper as mentioned earlier. If R3-R6 are all close tolerance resistors, the instrument will now read correctly on all ranges.

Linear Scale Capacitance Meter

There are certain similarities between this circuit (Figure 7) and that of the linear ohmmeter. The obvious difference is that the unknown is in the input rather than in the feedback path. Since it is capacitance that is being measured, the technique will be an a.c. one so that a source of alternating signal will be required whose frequency is variable. Apart from this, the method depends upon the 'reactance X' of the unknown capacitor determining the amplifier gain when it is compared with a fixed resistor R2 whose value is 47kΩ. That is to say, amplifier gain G is equal to R2/X. When these are equal, the gain is unity and the meter can be calibrated to read full-scale under these conditions. Since G is proportional to 1/X and X is proportional to 1/C, ($X = 1/2\pi fC$), then G is directly proportional to C and the scale is linear. RV1 is used to calibrate the meter and can be adjusted to give full-scale with a known value of Cx = 10nF in circuit and an input of 1V r.m.s. at a frequency of 338Hz. The range of capacitance quoted stops at 100nF because a further decade up to 1μF would mean an input frequency of only 3.38Hz unless some other factor can be changed. This 'other factor' is the amplitude of the input voltage. If this is reduced 10:1 to 100mV while the frequency is kept at 33.8Hz, a further range up to 1μF full-scale is created.

The main difficulty of the design is the need for a variable input frequency. The significance of this requirement depends upon one's facilities. If an audio-signal generator is available then this can be used, provided that both frequency and amplitude can be monitored with a reasonable degree of accuracy. Failing this, a switched-frequency oscillator with pre-set output amplitude would have to be constructed. This could be based on the op-amp Wien bridge circuit with the capacitor values switched to give the required frequencies. At least it gives one the chance to apply some of the ideas in Part Three of this series.

Say it with SATELLITES

Part 3

by Mike Wharton

More Ups and Downs!

The interval between the appearance of these articles is a long time in terms of space exploration, and what follows may well be out of date by publication. Despite this not being the latest 'hot space news', it is useful to look back on some events of the recent past.

The U.S. Space Shuttle has now successfully launched its first commercial pay-load, a couple of communications satellites, and its future now looks reasonably secure. The Russians are never slow to miss a trick, and were able to steal a march on the Americans by launching the first satellite in this manner. The tiny ISKRA-2 (Russian for 'spark'), satellite was launched from the air-lock of the Salyut/Soyuz orbiting space station back in May 1982. It never really did anything worthwhile, and, due to its low orbit, fell back to Earth a few weeks later.

One of the more spectacular 'downs' of the last few months was the attempt to put a pay-load into orbit using the European Ariane launcher. The two satellites, Marecs-B and Sirio-2, unfortunately ended their flight at the bottom of the Atlantic Ocean, possibly due to the failure of a fuel pump. This has been something of a major set-back for the European launcher programme, which is intended as a commercial competitor to the U.S. Space Shuttle.

The launch site for this venture is at Kourou in French Guiana, South America. This site is interesting, being only about 5 degrees North of the Equator. By utilising the added velocity of the earth's rotation to the launch velocity, a 17% 'throw weight' advantage is obtainable over Cape Canaveral. At the moment, however, this must be cold comfort to those involved in preparing Ariane, which still seems beset by development troubles.

OSCAR-9 is back!

Not that it ever went away, but this latest of a series of Amateur satellites has had its problems. During the time between this and the first article of the series, UOSAT/OSCAR-9 has been effectively 'off the air'. At the time of its launch, now well over a year ago, it was expected to provide a stimulus for interest in satellites by schools and colleges. Fortunately, control of the craft has now been regained, and attempts to stabilise its orbit should have been completed successfully. This satellite contains a number of interesting scientific experiment packages, including a TV type camera and a Speech Synthesiser. The camera is intended to produce pictures with a resolution of about 2km, but it remains to be seen if this hitherto untried method of obtaining a 'satellites — eye — view' of earth will prove to be successful.

The second experiment mentioned above is intended to transmit data from some of the other experiments on board in the form of synthesised speech. Again, at the time of writing, this has yet to give a proper account of itself! If UOSAT/OSCAR-9 proves to be of continuing interest, and these experiments can be made to work properly, more details of their reception may be given in a subsequent article. In the mean time, its telemetry beacon may be heard on a frequency of 145.825 MHz, if you possess a suitable receiver; the signal strength from the satellite is quite good, and it can be picked up on a 'hand-held' receiver on close passes. This brings us neatly to the next problem, that of finding out when an orbiting satellite is passing overhead.

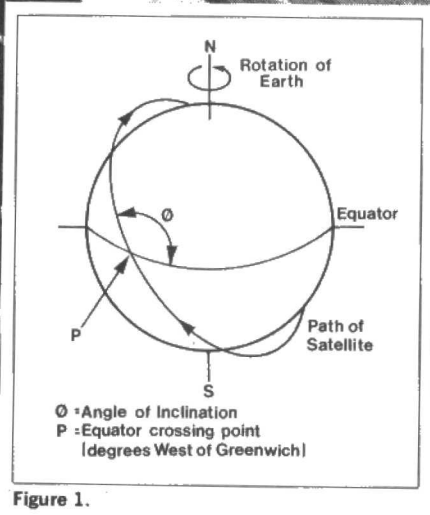


Figure 1.

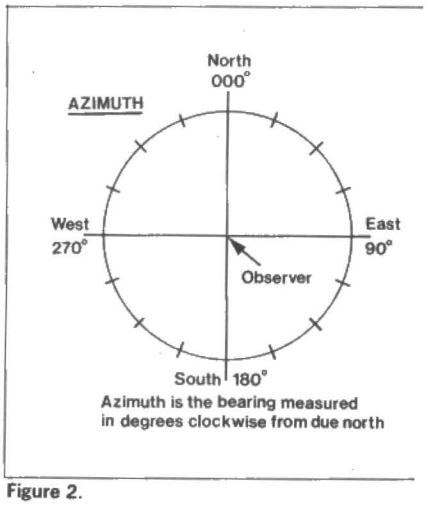
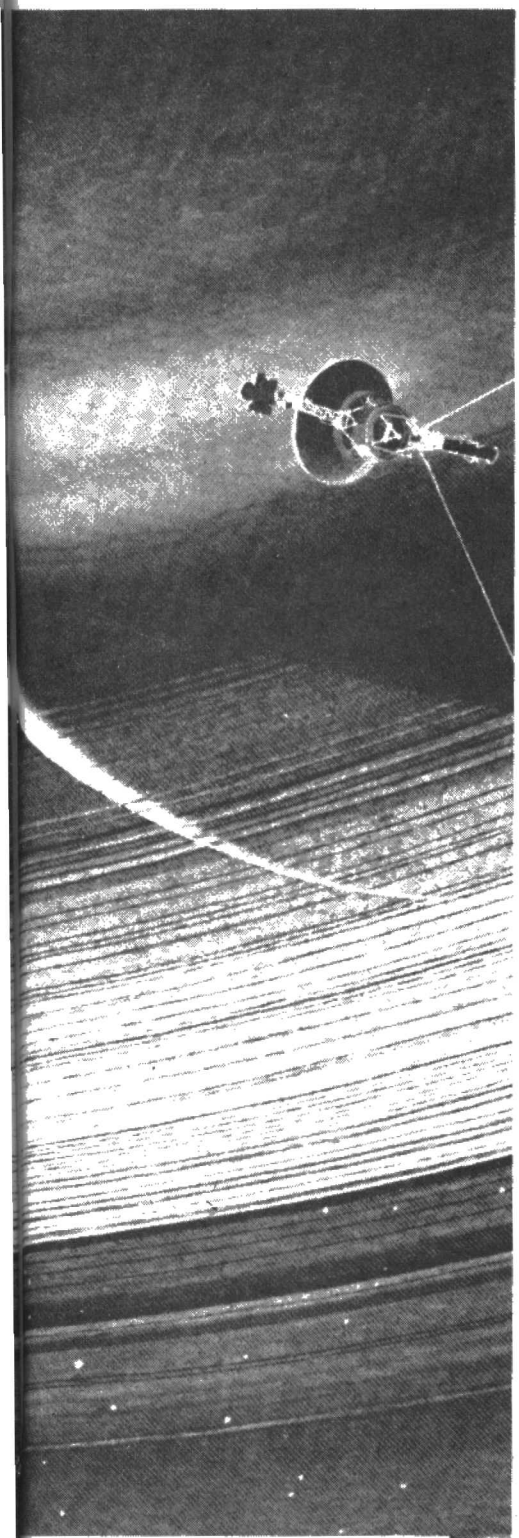


Figure 2.



Where are all the Satellites?

There are many ways of determining the path of an orbital satellite, from the use of special maps and projections to complicated trigonometry; a simple method is to set up a receiver tuned to the appropriate frequency and to wait for the arrival of the signal, hardly a method to be recommended, though. For anyone with access to a home computer, this possibly represents one of the most convenient ways, for even the much maligned ZX-81 has better computing power in this respect than the Petappletandy machines. Before looking in more detail at this method, let us consider the problems involved, without getting bogged down in any maths.

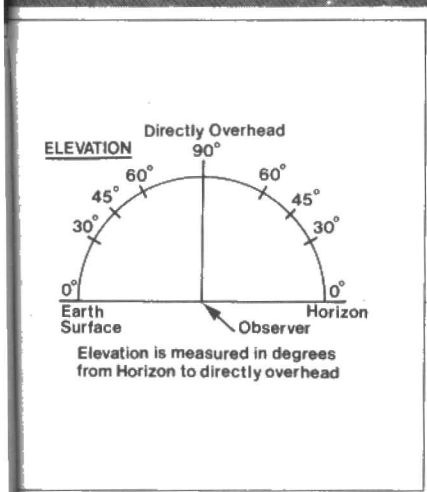
The best 'viewpoint' from which to look at the problem is that of someone in outer space, when the earth/satellite system would look like that shown in Fig. 1. Most of the orbital satellites have trajectories which carry them in more or less circular orbits towards the North and South Poles; those satellites with highly elliptical orbits are difficult to predict, and will not be considered here.

In defining the orbit of a satellite there are certain parameters which must be known; the time taken for it to travel once round the earth is called the Period, and twice in each circumnavigation the satellite crosses the Equator. The time at which it crosses on its North-bound journey is a useful reference point, usually given as the Equator Crossing Time. It is also necessary to know the Altitude, or height above the earth's surface, of the satellite. Whilst the satellite is orbiting the earth, this, too, is rotating on its axis once every 24 hours and must be taken into account in the calculation. Thus if, for example, a satellite crossed the Equator at exactly midday, and its Period was 60 minutes, then it would cross the Equator going in the same direction at 13:00 hours.

During this time the earth would have rotated through 15 degrees, i.e. 360/24. Thus if the Longitude at which the satellite crossed the Equator is known, then the crossing point and time can be predicted for subsequent orbits. Not everyone, of course, lives on the Equator, and we need to be able to preduct passes over the British Isles. For this we also need to know the Angle of Inclination of the orbit, shown as Ø in Fig. 1. The task of calculating the position of the satellite then resolves into two parts, that of finding its position over the surface of the earth, and then exactly which location will be underneath the path at a particular time.

It is not necessary to be directly below an orbiting satellite in order to receive a radio signal from it (incidentally, they are all too small, too high and moving too fast ever to be seen with the naked eye). Thus, depending on the altitude of the satellite, signals should be of adequate strength as it rises over the horizon and passes either to one side or the other, fading away as it then sets below the horizon. If one is attempting to receive the signals on a directional antenna, such as a 2-metre Yagi, then it is important to have some idea of the path which the satellite will describe as it passes by, so that the antenna may be tracked round to follow the source of the signal. To do this, one needs information on the Azimuth and Elevation of the satellite as it passes overhead. Fig. 2 explains these two terms; Azimuth is used to describe the position of the satellite with respect to an observer standing at the centre of a circle, with due North being zero (and 360 degrees) and South being 180 degrees. The Elevation is the 'height', in degrees, which the satellite attains during its pass, with the horizon being at zero degrees and a point directly overhead being at 90 degrees. The use of a globe of the earth may be helpful in trying to visualise all these aspects of the problem.

In order to determine the Azimuth and Elevation of an orbital satellite as it passes close by then, one needs to know the time and Longitude of its Equator Crossing, the Period, its Inclination, its Attitude and your own Latitude and Longitude. These last two are fairly easy to find by using an Atlas, but the other information can be more difficult to come by. This is aggravated by the fact tha the parameters are constantly changing, for although space is usually regarded as being empty, there is sufficient material to exert a drag on the satellite and gradually slow it down. This means that it is not possible to predict satellite passes too far into the future without continually updating the relevant parameters. For this reason it is suggested that any preliminary attempts at satellite tracking be made on the above mentioned UOSAT/OSCAR-9, since the University of Surrey provide a source of up to the minute information. This can be obtained for the price of a phone call, to Guildford 61202, where a recorded message will give the latest orbital parameters. You may find it difficult to copy them down correctly the first time, as the information comes thick and fast, and it is suggested that a cassette recorder is rigged up to tape the message. Table 1 gives the orbital parameters and Equator Crossing time as of the 4th January 1983.

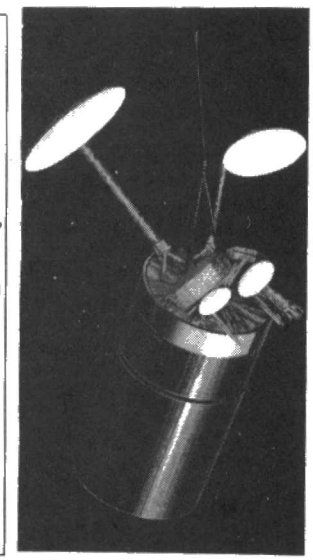


gure 2.

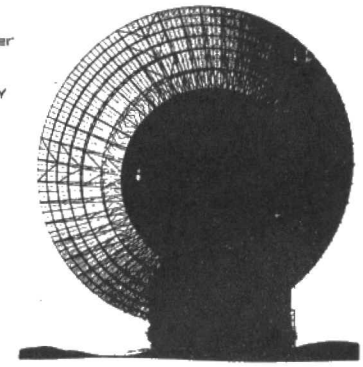
Table 1
Orbital Parameters and Data for 4th January 1983

Period: 95.708656 minutes — MEAN ALTITUDE: 550km
Inclination: 97.46° — Longitude increment: 23.93°

Orbit No:	Equator Crossing Time (hours:mins:secs)	Equator Crossing Point Degrees West of Greenwich
6890	13:09:17	330.50
6891	14:44:59	354.43
6892	16:20:41	18.36



```
L.
   10 REM AZIMUTH/ELEVATION TABLE FOR OSCAR-9
   20 CLS
   30 PRINTTAB(12,2);"OSCAR 9 AZ-EL"
   40 PRINTTAB(3,10);"What is the LATITUDE of your station. Enter in Degrees NOR
TH",:INPUT LA
   50 CLS
   60 PRINTTAB(3,10);"What is the LONGITUDE of your station? Enter in Degrees We
st.":INPUT LO
   70 CLS
   80 LET L=LA*PI/180
   90 LET G=LO*PI/180
  100 CLS
  110 PRINTTAB(3,10);"PLEASE ENTER THE TIME OF EQUATOR CROSSING AS HHMM (EG 0945
)"
  120 INPUT X$
  130 IF VAL X$<0 OR VAL X$>2400 THEN GOTO 110
  140 CLS
  150 PRINTTAB(3,10);"PLEASE ENTER EQUATOR CROSSING BEARING IN DEGREES WEST (EG
30.2)"
  160 INPUT W
  170 CLS
  180 PRINTTAB(12,1);"OSCAR 9 AZ-EL"
  190 PRINTTAB(0,3);"EQX ";X$;" Bearing ";W;" Degrees West for          Station at
  Longitude  ";LO;" and Latitude ";LA,
  200 PRINTTAB(1,6)"TIME ";TAB(13);"AZIMUTH";TAB(25);"ELEVATION"
  210 PRINT,,
  220 LET T=6
  230 LET B=ASN(0.99153*SIN(2*PI*T/95.708656))
  240 LET C=ACS((COS(2*PI*T/95.708656))/(COS B ))+(T/4+W)*PI/180
  250 LET T=T+2
  260 IF T>45 THEN GOTO 370
  270 LET Z=ABS (C-G)
  280 IF Z>PI THEN LET Z=ABS(2*PI-Z)
  290 LET D=ACS (SIN L*SIN B+COS L*COS B*COS Z)
  300 IF D>0.4 THEN GOTO 230
  310 LET AZ=57.3*(ACS((SIN B-SIN L*COS D)/(COS L*SIN D )))
  320 IF C>G AND C<(PI+G) OR C>(2*PI+G) OR C<(G-PI)THEN LET AZ=360-AZ
  330 LET EL=(PI/2-(ATN(6921*SIN D/(6921*COS D-6371))))*57.3
  340 GOSUB 420
  350 PRINTTAB(2);T$;TAB(16);INT (AZ);TAB(29);INT(EL)
  360 GOTO 230
  370 PRINT "END"
  380 PRINT "Do you wish to process another set of data for this location? Answer
  Y/N":INPUTA$ :IF A$="Y" OR A$="N" THEN GOTO 390 ELSE GOTO 380
  390 IFA$="Y"THEN GOTO 100
  400 PRINT "Do you wish to alter the Latitude and Longitude?":INPUT A$:IF A$="Y
"THEN GOTO 20
  410 STOP
  420 LET X=VAL(X$)
  430 LET X=X+T-2
  440 LET X1=X-(INT(X/100))*100
  450 IF X1>=60 THEN LET X=X+40
  460 IF X>2400 THEN LET X=X-2400
  470 LET V$="0000"
  480 LET T$=STR$(X)
  490 LET Y=4-LEN(T$)
  500 LET Z$=LEFT$(V$,Y)
  510 LET T$=Z$+T$
  520 RETURN
```



APPENDIX 1

```
OSCAR 9 AZ-EL
EQX 1309 Bearing 330.5 Degrees West for          Station at Longitude  2 and Lati
tude 52
TIME          AZIMUTH      ELEVATION

  1319          122            1
  1321          109            8
  1323          82             17
  1325          42             17
  1327          14             9
  1329          0              1
END
OSCAR 9 AZ-EL
EQX 1445 Bearing 354.43 Degrees West for          Station at Longitude  2 and Lat
itude 52
TIME          AZIMUTH      ELEVATION

  1453          177            0
  1455          182            10
  1457          195            28
  1459          272            52
  1501          328            23
  1503          339            8
END
OSCAR 9 AZ-EL
EQX 1620 Bearing 18.36 Degrees West for          Station at Longitude  2 and Lati
tude 52
TIME          AZIMUTH      ELEVATION

  1630          239            0
  1632          258            4
  1634          281            5
  1636          304            3
END
```

APPENDIX 2

Computer Program

The program given in Appendix 1 has been written for the BBC Computer, but it is possible by taking account of changes in syntax to configure it for many other machines. The only possible problem will be with those machines which do not contain the functions for Arcsine (ASN), Arccos (ACS), or Arctan (ATN).

When Run, the program should give a table of Times, and the corresponding Azimuth and Elevation over 2 minute intervals for the particular pass. Not every pass given in the UOSAT Bulletin will be visible from every point in the British Isles, but to obtain the Time and Equator Crossing Longtitude for consecutive orbits, it is only necessary to add on the time of one Period and then work out the angle through which the earth will have rotated in this time.

Using this method it is possible to work out the Equator Crossing Times for Longtitudes around 180 degrees West, and putting these into the program where requested will give the plot for those passes of a North-South direction. Finally, Appendix 2 shows a sample plot for UOSAT/OSCAR-9 using the data for Equator Crossing Time and Longtitude given in Table 1, for an earth station located at 52 degrees North, 2 degrees West. It is recommended that a trial run be made with this data first, to make sure no errors have sneaked in during typing, and if these results cannot be reproduced then check the program before proceeding further. Good hunting!

ROAD TESTING THE M5

continued from page 14

able, but we are unable to determine whether it was possible to address these locations directly with BASIC-I.

Many people will want to write machine code programs and an assembler will be available for this. Since BASIC is not built into the machine, a full 55.25K of RAM (once extended) is available to the machine code programmer, and don't forget that none of this is wasted for screen display maps, since this can all be contained in the video processors own separate 16K of RAM.

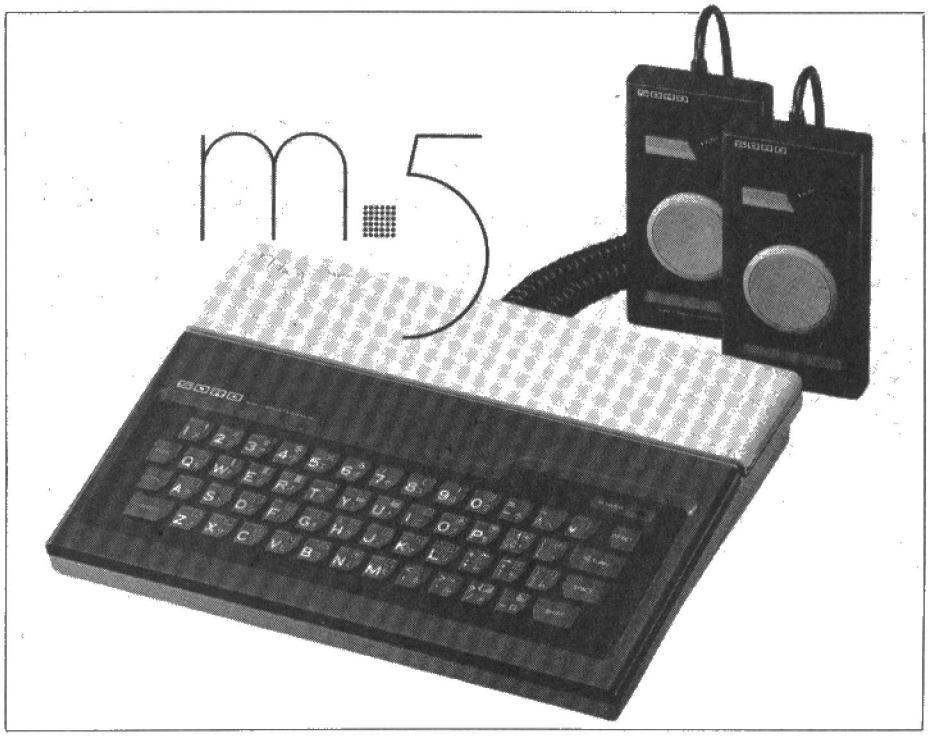
Utilities

Two utility programs will be available on cassette as an aid to using the video processor. With the first utility an image is created on the screen then saved to cassette. Sprites for animation are registered int the sprite area of the video processor before program execution, then the program is executed. The user can create any scene or design they wish.

The second utility generates the background colours and images. The program creates and registers the colours in the same way as the sprite utility. These utilities can be used with BASIC -I and so do not require either understanding or use of the more complex BASIC-G.

Instruction Manuals

Although not yet printed, I was assured by the manufacturers that the technical documentation and instruction guide supplied with the machine reach a very high standard. Operation of the M5 is carefully and simply explained even for the absolute novice.

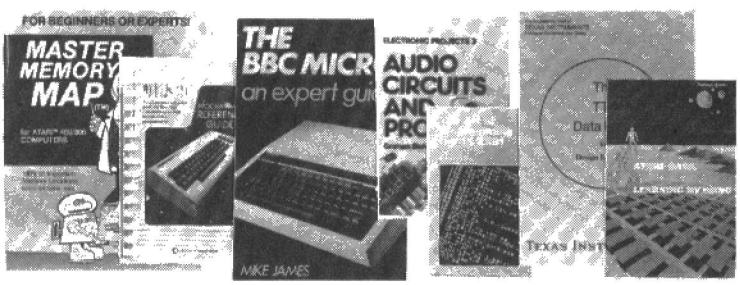


A separate book is available with the monitor listing and source listing for BASIC-I. The book explains how the monitor operates and how BASIC-I is programmed. A further book is available giving a complete description of the M5 hardware.

Computer Games Limited, the people who sell Activision in the UK have won the rights to sell this remarkable little machine in the home computer market. It should sell for around £190 including VAT and offers a lot of power for this price. Later in '83 a 3½ inch disk drive with over 100K capacity selling for about £100 will become available, the first of a new breed of miniature disk drives. With high density storage available at this very low price, the M5 will be a very serious contender in the home computer market.

Maplin are expecting their first deliveries of the M5 in April or May this year.

MAPLIN'S TOP TWENTY BOOKS



1. (3) Games for the Atari by S. Roberts (WA47B) (cat. P62)
2. (1) De Re Atari (WG56L) (cat. P62)
3. (-) Master Memory Map (XH57M) (cat. P62)
4. (-) Audio Circuits and Projects by Graham Bishop (XW46A) (cat. P41)
5. (9) Cost Effective Projects around the Home by John Watson (XW30H) (cat. P41)
6. (12) Projects for the Car and Garage by Graham Bishop (XW31J) (cat. P30)
7. (2) Atari Computer Operating System Users Manual and Hardware Manual (WA46A) (cat. P62)
8. (-) Atari BASIC Learning by Using by Thomas E. Rowley (WG55K) (cat. P62)
9. (-) The BBC Micro - An Expert Guide by Mike James (WK04E) (cat. P63)
10. (17) Atari Sound and Graphics by Herb Moore, Judy Lower, and Bob Albrecht (WA39N) (cat. P62)
11. (7) Programming the 6502 by Rodnay Zaks (XW80B) (cat. P54)
12. (-) VIC Programmers Reference Guide (WA33L) (cat. P63)
13. (8) Power Supply Projects by R. A. Penfold (XW52G) (cat. P38)
14. (6) Electronic Synthesizer Projects by M. K. Berry (XW68Y) (cat. P50)
15. (14) Adventures with Micro-Electronics by Tom Duncan (XW63T) (cat. P30)
16. (-) The TTL Data Book (WA14Q) (cat. P33)
17. (4) Towers' International Transistor Selector Update 2 by T. D. Towers (RR39N) (cat. P32)
18. (-) The Art of Programming the 1K ZX81 by M. James and S. M. Gee (WA38R) (cat. P64)
19. (9) IC555 Projects by E. A. Parr (LY04E) (cat. P39)
20. (10) Newnes Radio and Electronics Engineers Pocket Book (RL06G) (cat. P30)

These are our top twenty best-selling books based on mail-order and shop sales during November and December 1982 and January 1983. Our own publications and magazines are not included. We stock over 450 different books relating to electronics or computing, and the full range is shown on pages 29 to 65 of our 1983 catalogue. For prices see page of this magazine.

COMING IN THE NEXT ISSUE. . .

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BASICALLY BASIC

Part 15

Graham Hall, B.Sc.

In the final part of this series a summary of the most widely available BASIC statements, functions and operators will be given. The descriptions do not apply to any one version of BASIC, this can only be done by your system's user guide, but aim to give a general overview of the facilities available in BASIC; hence some of the statements or functions described may not be available in the version of BASIC that you are using.

Statements

In the definitions to follow the format of each BASIC statement is defined in the context of a program line. A statement can consist of several 'elements' or portions — in these definitions, elements in angle brackets < > are required, elements in square brackets [ ] are optional and elements in braces { } represent a choice of elements, one of which is required.

The elements and their abbreviations are:

variable (var)	Any legally named BASIC variable
line number	Any legal BASIC line number
expression (exp)	Any legal BASIC expression
message	Any combination of characters
condition (cond)	Any relational condition
argument (arg)	A dummy variable name
statement	Any legal BASIC statement
string	Any legal BASIC string constant or string variable
list	The legal list for that particular statement
dimension	One or two dimensions of an array

Statement Format and Example

REM (comment statement)
line number REM [message]
10 REM COMMENTS ARE IGNORED BY THE COMPUTER

LET (assignment statement)
line number [LET] < var > [, < var > , < var > . . .] = < exp >
150 LET B = 4 * A * D
160 C = 100

DIM (dimension statement)
line number DIM < var (dimensions) > [, < var (dimensions) > , . . .]
50 DIM Z$ (6, 10), A (50)

IF THEN, IF GOTO (conditional statement)
line number IF < cond > { THEN < statement > / THEN < line number > / GOTO < line number > }
20 IF X > Y THEN PRINT "WARNING!"
30 IF Z = 0 THEN 990
40 IF Z = 0 THEN GOTO 990

FOR (loop statement)
line number FOR < var > = < exp > TO < exp > [STEP < exp >]
70 FOR J = **-1 TO 19 STEP 2**
80 FOR J = A TO 10

The FOR statement initialises a loop. Together with its corresponding NEXT statement, it controls the execution of the statements between the FOR and the NEXT statement. A simple numeric variable must be used after the FOR, and the same variable must appear in the NEXT statement. The first numeric expression is the 'initial loop value'; the second expression is the 'terminating loop value'. The STEP expression is the optional 'loop increment value'. If it is not specified a default value of one is assumed. Transfer by a GOTO statement into an uninitialised loop is not allowed. Placing one loop inside another is called 'nesting'. BASIC allows several levels of nesting.

NEXT
line number NEXT < var >
10 NEXT J

The NEXT statement terminates a FOR loop. The variable must be the same as the variable in the corresponding FOR statement.

DEF (definition statement)
line number DEF FN < var > (arg) = < exp (arg) >
30 DEF FNT (X) = (9/5) * X + 32

The DEF statement establishes a user defined function. The function type is determined by the variable type following the characters FN (i.e. if a string variable is specified the DEF statement defines a string function).

GOTO (unconditional branch statement)
line number GOTO < line number >
20 GOTO 190

The GOTO statement unconditionally transfers control to a specified line number.

ON GOTO (semiconditional branch statement)
line number ON < exp > GOTO < list of line numbers >
15 ON X GOTO 10, 70, 90, 5

The ON GOTO statement is used to branch to one of a list of specified lines based on the result of an expression.

GOSUB (call subroutine statement)
line number GOSUB < line number >
30 GOSUB 600

The GOSUB statement transfers control to a subroutine that begins at a specified line number.

ON GOSUB (semiconditional branch to a subroutine statement)
line number ON < exp > GOSUB < list of line numbers >
35 ON Y GOSUB 600, 1120, 900

The ON GOSUB statement is used to transfer program control to one of a list of subroutines based on the result of an expression.

RETURN (return from subroutine statement)
line number RETURN
70 RETURN

The RETURN statement is the last executable statement in a subroutine. It transfers control to the statement following the last executed GOSUB statement.

CHANGE (string conversion statement)
line number CHANGE { < array name > / < string var > } TO { < string var > / < array name > }
50 CHANGE A$ TO F
80 CHANGE M TO R$

The CHANGE statement converts a list of integers (real numbers are truncated) into a string of characters and vice versa. Element 0 of the list contains the value representing the length of the string.

READ (read data statement)
line number READ < list of variables >
35 READ X, Y, Z$

The READ statement is used to assign data to variables from a list of values built into a data block by a DATA statement. The assignment is made as the program runs.

DATA (data specification statement)
line number DATA < list of values >
125 DATA 3.14, 8.21, "STRING", -1

The DATA statement is used to provide a pool or block of information to a program in conjunction with the READ statement. Each data item in the list is separated with commas.

RESTORE (reset data statement)
line number RESTORE
90 RESTORE

The RESTORE statement enables the same values in the DATA statement to be used for more than one READ statement variable. It does this by moving a pointer which points to the next available data item in the DATA list, back to the beginning of the DATA list.

PRINT (output data statement)
line number PRINT [< exp > , < list >]

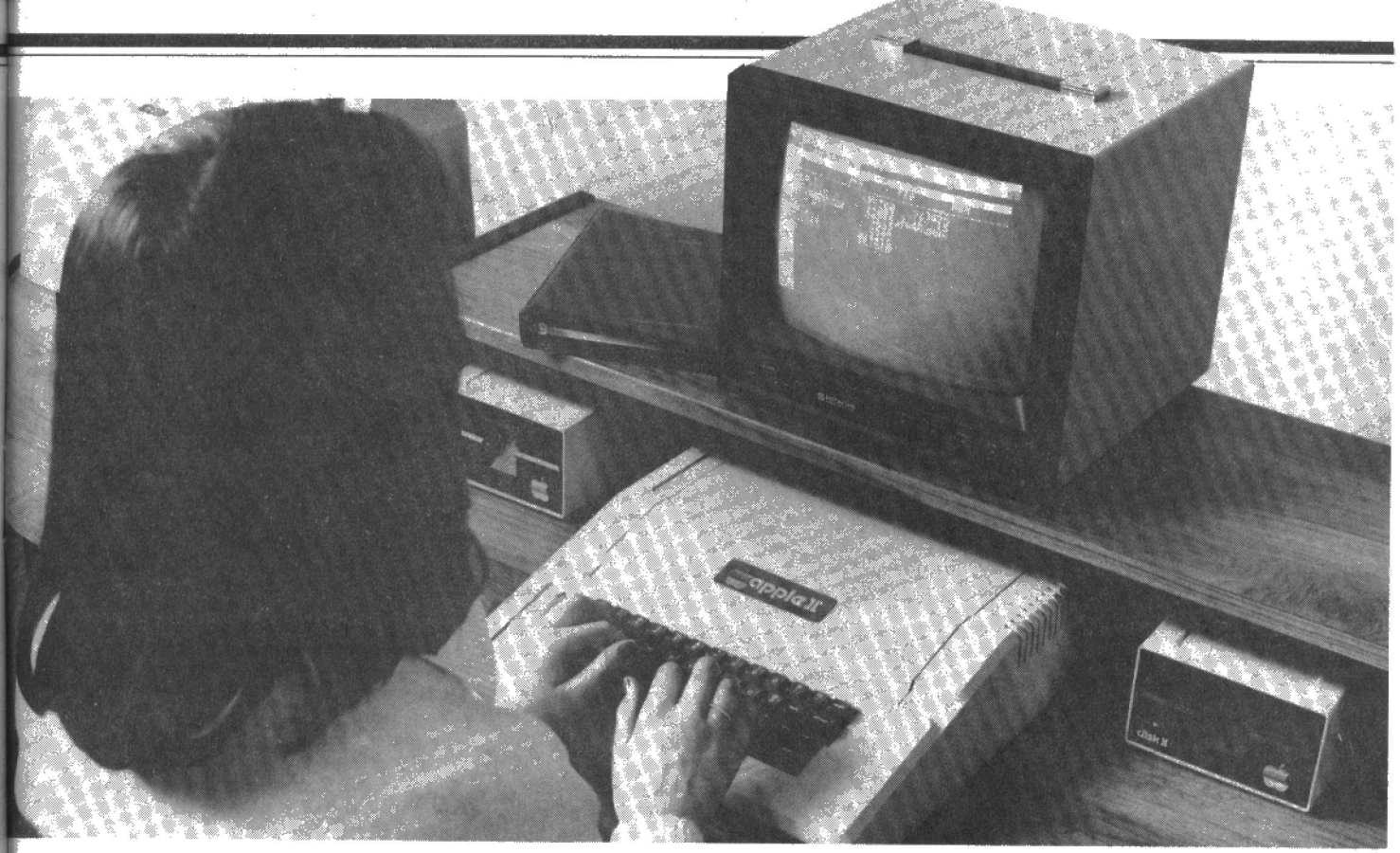
65 PRINT "RESULTS", G, H + 11

The PRINT statement outputs the specified data to the terminal. The expression list can be expressions, variables, or quoted strings separated by a comma or a semicolon. Commas cause the output to terminal fields or columns; semicolons ignore the fields. If the PRINT statement is used without a following expression a blank line is output to the terminal.

INPUT (data input statement)
line number INPUT [< string >,] < list >
30 INPUT "TIME & DATE", T$

The INPUT statement is used to assign data to a program from the terminal when the program is run. The program requests data by printing a question mark on the terminal and then waiting for characters to be input.

STOP (suspend program execution statement)
line number STOP
35 STOP



The STOP statement is used to temporarily halt program execution enabling the results of the program up to the point of the halt to be checked. Files remain open and a message indicating the location of the halt is printed on the terminal. The execution of the program can be continued by typing CONTINUE.

END (program terminator statement)

line number END

4Ø95 END

The END statement terminates program execution. It must appear as the last statement in the program.

OPEN (open file statement)

line number OPEN <string> { FOR INPUT / FOR OUTPUT } AS FILE # <exp>

1Ø OPEN "RESULTS" FOR INPUT AS FILE # 1

2Ø OPEN "KEYDATA" FOR OUTPUT AS FILE # 2

3Ø OPEN "DATES" AS FILE # 3

The OPEN statement enables a new file, or an existing file, to be opened and associated with a file number which establishes a communication channel between the program and the file.

CLOSE (close file statement)

line number CLOSE # <exp> [, # <exp>]

175 CLOSE #1, #2, #3

The CLOSE statement is used to close a file and dissociate it from a communication channel. When no file numbers are specified all opened files are closed.

PRINT # (write data to file statement)

line number PRINT # <exp>, <list>

9Ø PRINT #3, A$; ","; B

The PRINT # statement is used to write data to a file associated with the communication channel number specified.

INPUT # (read data from a file statement)

line number INPUT # <exp>, <list>

The INPUT # statement is used to retrieve data from an opened file to use as input to the program. The INPUT # statement line that retrieves data from a file must duplicate the format of the PRINT # statement that wrote the data.

Functions and Operators

Functions are pre-written routines that perform commonly used operations. The following tables list the Math, Print and String functions and the Logical, Arithmetic and Relational Operators available in BASIC.

Function	Description
ABS (X)	Returns the absolute value of X.
ATN (X)	Returns the arctangent of the value X in radian measure.
COS (X)	Returns the cosine of the radian value X.
COT (X)	Returns the cotangent of the radian value X.
EXP (X)	Returns the numeric constant 'e' (2.71828) raised to the power of X.
INT (X)	Returns the largest integer value of X.
LOG (X)	Returns the natural logarithm of the value X.
POS (X)	Returns the current position on the output line.
RND (X)	Returns random numbers.
SGN (X)	Returns an indication of the sign (+, - or Ø) of X.
SIN (X)	Returns the sine of the radian value X.
SQR (X)	Returns the square root of X.
TAB (X)	Causes output to be printed at the X column on the output line.
TAN (X)	Returns the tangent of the radian value X.

Math and Print Functions.

Function	Use
ASC (X$)	Converts the first character in the string, X$, to its equivalent ASCII value.
CHR$ (X)	Converts the ASCII code number, X, to its equivalent character.
LEFT (X$, n)	Indicates a portion of the specified string, X$, in a range from the left-most character to the nth character.
LEN (X$)	Indicates the number of characters in the specified string, X$.
MID (X$, n1, n2)	Indicates a substring in the specified string, X$, that begins at position n1 and is n2 characters long.
RIGHT (X$, n)	Indicates a substring in the specified string, X$, in the range of n to the right-most character.
SPACE $ (n)	Produces a string of n spaces.
STRING $ (n1, n2)	Creates a string that is n1 characters long and is composed of the characters specified by the ASCII code, n2.
VAL (X$)	Computes the numeric value of the numeric characters contained in the specified string, X$.

String Functions.

Table 3. Arithmetic Operators.

BASIC symbol operator	Arithmetic operation	Example	Description
+	addition	X + Y	add Y to X
-	subtraction	X - Y	subtract Y from X
*	multiplication	X * Y	multiply X by Y
/	division	X/Y	divide X by Y
^or↑ or **	exponentiation	X^ Y	raise X to the Yth power

Operator	Use	Meaning
NOT	NOT X	logical negative of X
AND	X AND Y	logical product of X and Y
OR	X OR Y	logical sum of X and Y
X OR	X X OR Y	logical exclusive OR of X and Y

Logical Operators

Mathematical Symbol	BASIC Symbol	Example	Meaning
+	=	X = Y	X is equal to Y
<	<	X<Y	X is less than Y
≤	<= or =<	X<=Y	X is less than or equal to Y
>	>	X>Y	X is greater than Y
≥	>= or =>	X>=Y	X is greater than or equal to Y
≠	<>or><	X<>Y	X is not equal to Y

Relational Operators.

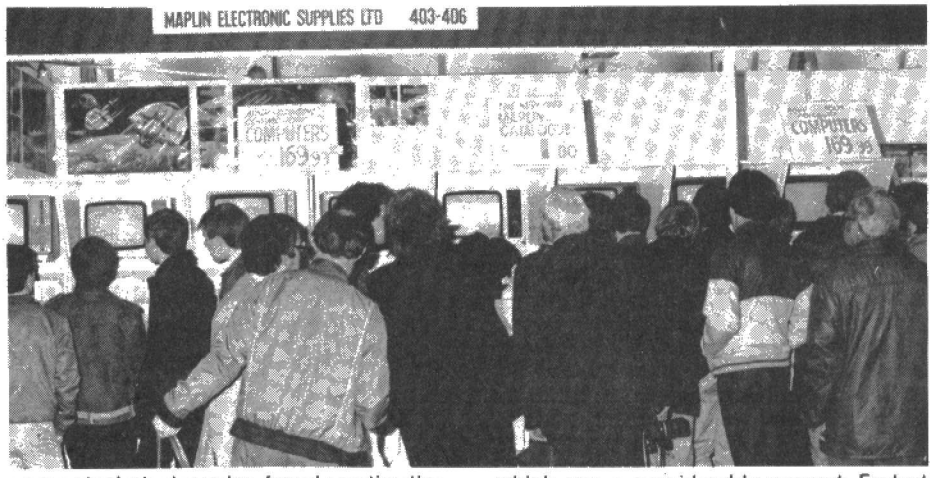
COMPUTER NEWS

The Northern Computer Fair

Thank you to all the people who supported our stand at the Northern Computer Fair, we were amazed and extremely pleased at the response and hope to see all of you again next year. Manchester is definitely on our list of new sites for shops!

The organisers did an excellent job, the hall was light, spacious and airy, with plenty of room for everyone, the facilities were some of the best we have seen at an exhibition, and even the security guards were helpful! All these, plus the fact that we were extended such a warm welcome, combined to make this a highly enjoyable event.

Once again the Ataris, with their high degree of visibility, were the main attraction, but when people had been drawn to our stand a lot of interest was displayed in the books and software, with the Maplin Modem receiving quite a bit of attention. Our stand was also one of those filmed by Granada Television for their 'Granada Reports' programme, so we may have reached an even wider audience than originally hoped for.



Our technical staff, who were on hand to answer technical queries, found meeting the computer-using public 'face-to-face' a useful experience. They were also surprised at how knowledgeable everybody was, especially some of the children. The level of computer awareness in schools is obviously rising rapidly.

The 1983 Maplin catalogue proved very popular, and we sold all that we took with us, which was a considerable amount. Fastest selling computer was the Atari 800 with 48K RAM, and we noticed an increase in the sales of disk-based software, with Star Raiders still the favourite title, but being chased by Choplifter and SAM.

Thank you, once again, to everyone who came along to see us. We hope that you enjoyed it as much as we did.

COMING SOON

THE Midland Computer Fair
Personal computers
Home computing
Small business systems

Bingley Hall, Birmingham April 28th to 30th 1983

Following the outstanding success of the Northern Computer Fair, Maplin are pleased to announce that they will also be exhibiting at the new Midland Computer Fair, which takes place at Bingley Hall, Birmingham, from the 28th to the 30th of April. The doors will be open from 10 a.m. to 6 p.m. on the 28th and 29th, and from 10 a.m. to 5 p.m. on the 30th. The fair is all about personal computers, home computing, and small business systems, and we hope that all our customers and readers in the Midlands will come and see us.

The Maplin stand will be showing our extensive (and ever-increasing) range of computers and software, all of which will be available for purchase. If you come along you will be able to try out many of these for yourself, as we will be having our usual 'customer participation' displays.

You will also be able to buy not only the 1983 Maplin catalogue, but also a whole host of books and literature on computers and related subjects. Free leaflets on hardware and software will also be placed about the stand, so nobody should go away empty-handed. Our technical staff will also be at hand to answer any queries you may have concerning computers and electronics in general.

The Scottish Personal Computer World Show

MacRobert Pavilion, Edinburgh April 16-18, 1983

At last — a chance for all those of you 'north of the border' to visit a personal computer show without having to travel to the other end of the country. Edinburgh is host for the first time to a show which covers all sectors of micro computer applications.

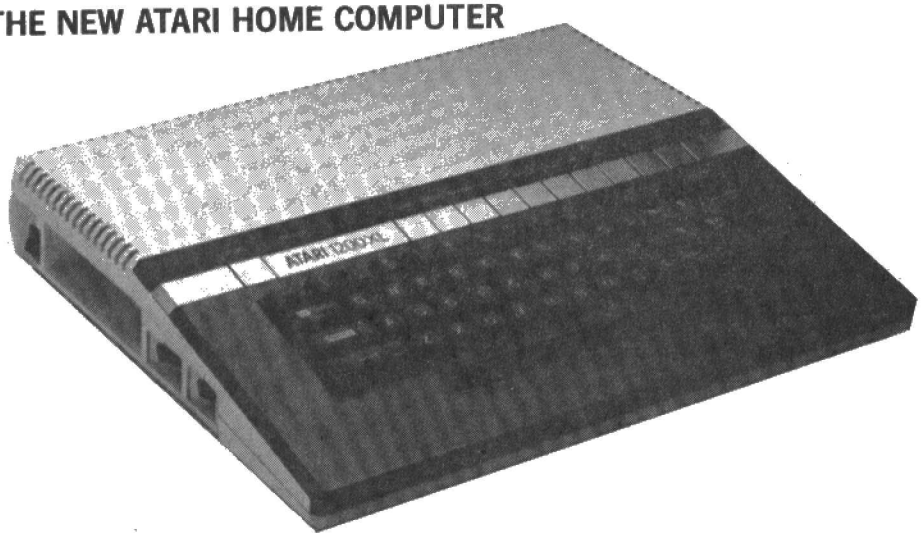
The show is at the MacRobert Pavilion, which is part of the Ingliston Exhibition Complex, adjacent to Edinburgh Airport, and is being held alongside the Scottish Ideal Home Exhibition. The Pavilion offers the finest setting for an exhibition outside London or Birmingham, and no parking problems! There is plenty of space within the immediate vicinity, and you should have no trouble finding room for your car. There is a regular bus service too!

The show is being held from the 16th to the 18th of April, which is a holiday weekend in the Glasgow/Edinburgh area, and the opening hours are from 10 a.m. to 9 p.m. on the 16th, 10 a.m. to 6 p.m. on the 17th, and 10 a.m. to 5 p.m. on the 18th. Tickets will cost £2.50, and there will be a joint ticket for both events available at a reduced rate, although details of pricing have not yet been finalised.

All the usual Maplin goodies will be on demonstration and sale, including some items of software and hardware that are so new we don't even know their names yet! If you are finding it difficult to choose between the incredible variety of computers and software available, then our technical staff will be only too pleased to help you, and answer any questions you might have.

A representative of the Atari User Group will also be on hand to talk to those of you who have already bought, or are seriously thinking of investing in one of the Atari range of computers and peripherals. They would also be pleased to meet any current members of the group, and to hear their ideas for future issues.

THE NEW ATARI HOME COMPUTER

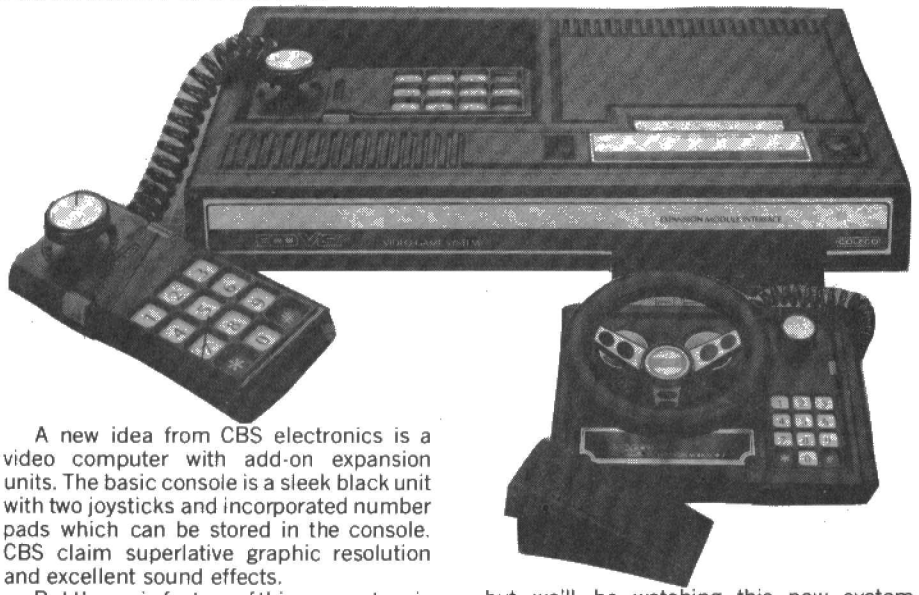


At the giant Consumer Fair in Las Vegas in January, Atari were showing for the first time their new 1200XL computer. Though it probably won't be launched in the UK until late 1984, the new computer is styled differently, but is otherwise almost identical to the 800. It will come fully equipped with 64K RAM which for normal use is the same as the 48K 800 but perhaps allows you to change the operating system. It has one or two little extras such as one touch cursor controls, a key marked "Help" which can be used to give useful instructions on selected programs and an electronic keyboard lock that prevents accidental entries or tampering.

The new machine has a self-test function, say Atari, but we were unable to discover what this actually was, and a foreign character set which Atari claim "lets you communicate in many European languages." When it is first released Atari say it will sell for about £550 — rather expensive. Nevertheless it seemed clear to us that there can only be one reason why Atari have launched a new machine so little different from the 800.

It doesn't become clear until you look inside the machine and when you see the single, neat circuit board it is obvious that it is much cheaper to manufacture than the 400 or 800. The machine has been launched it seems to us so that it can eventually be priced competitively with the machines that will be around in 1985 and 1986 and we would not be at all surprised to see the 1200XL selling for much less than the current 800 price, in a few years time.

NEW VIDEO COMPUTER GAME PACKAGE HAS EXPANSION MODULES



A new idea from CBS electronics is a video computer with add-on expansion units. The basic console is a sleek black unit with two joysticks and incorporated number pads which can be stored in the console. CBS claim superlative graphic resolution and excellent sound effects.

But the main feature of this new system is its add-on capability. The first add-on unit is an Atari converter. This will simply plug on to the front of the main console and allow you to use cartridges designed for the Atari Video Game.

The second add-on is a Turbo Drive Module which consists of a steering wheel, dashboard and accelerator pedal. This should make car race games exceptionally realistic and looks like a lot of fun.

The third add-on is a keyboard that turns the game into a home computer. We weren't able to get much information on this add-on, but we'll be watching this new system carefully as it could become very popular.

CBS will also be releasing lots of new games on cartridge and all will be available for Atari, Mattel Intellivision and their own unit. Games include Bally Midway's Gorf and Wizard of Wor, Sega's Turbo, Zaxxon and Carnival, Exidy's Mouse Trap and Venture, Universal's Ladybug and Cosmic Avenger, Peyo's Smurf Rescue in Gargamel's Castle and Nintendo's Donkey Kong.

The new system whose full name is CBS Colecovision is being distributed in the UK by Ideal Toys.

NEW SOFTWARE

A massive new selection of software has become available for our range of home computers since our 1983 catalogue was published. Unfortunately, there is insufficient space to describe it all, but issue 4 of our software leaflet (XH52G) will be published early March with descriptions of most of the new items. Alternatively many of the items for Atari, Commodore 64, Dragon, Spectrum and VIC20 are described in the new Mapsoft catalogue (XH60Q) price £1.

Atari

Choplifter	1E-16K-KB87U	£34.95
Embargo	1E-8K-KB43W	£34.95
Protector	1E-16K-KB88V	£34.95
Gorf	1E-16K-KB44X	£34.95
Stellar Shuttle	1C-16K-KB45Y	£23.50
Stellar Shuttle	1D-32K-KB46A	£23.50
Deluxe Invaders	1E-16K-KB89W	£31.95
Rear Guard	1C-16K-KB47B	£14.50
Rear Guard	1D-24K-KB48C	£17.95
Stratos	1C-16K-KB53H	£24.95
Stratos	1D-32K-KB54J	£24.95
Space Games	1C-32K-KB55K	£17.95
Space Games	1D-32K-KB56L	£17.95

Sea Fox	1D-48K-KB57M	£23.50
Sea Dragon	1C-16K-KB58N	£24.95
Sea Dragon	1D-32K-KB59P	£24.95
Shamus	1E-16K-KB90X	£34.95
Serpentine	1E-8K-KB60Q	£34.95
Bug Off	1C-16K-KB61R	£21.95
Bug Off	1D-32K-KB62S	£21.95
Tutti Frutti	1C-16K-KB63T	£17.95
Tutti Frutti	1D-32K-KB64U	£17.95
Genetic Drift	1C-16K-KB65V	£23.50
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Labyrinth	1D-32K-KB72P	£23.50
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TT Racer	1C-16K-KB73Q	£19.95
Baja Buggies	1C-16K-KB74R	£22.95
Baja Buggies	1D-16K-KB75S	£22.95
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David's Midnight Magic	1D-48K-KB78K	£27.50
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Clowns & Balloons	1D-16K-KB80B	£23.50
Guns Of Fort Defiance	1D-32K-KB96E	£18.95
Galactic Trader	1C-32K-KB25C	£14.50
GFS Sorceress	1C-48K-KB26D	£21.95
GFS Sorceress	1D-40K-KB27E	£25.95
Journey To The Planets	1C-32K-KB28F	£20.45
Journey To The Planets	1D-32K-KB29G	£20.45
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King Arthur's Heir	1D-40K-KB34M	£20.75
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Treasure Quest	1C-16K-KB36P	£10.95
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Alien Garden	1E-8K-KF00A	£27.45
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Hellfire Warrior (Part 1)	1D-32K-KF03D	£27.45
Danger In Drindisti (Part 2)	1C-32K-KF04E	£13.80
Danger In Drindisti (Part 2)	1D-32K-KF05F	£13.80
The Keys Of Acheron (Pt 3)	1C-32K-KF06G	£13.80
The Keys Of Acheron (Pt 3)	1D-32K-KF07H	£13.80
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Morloc's Tower	1D-32K-KF15R	£13.80
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Dig Dug	1E-16K-KF17T	£29.95
Atariwriter	1E-16K-KF18U	£59.95
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Zaxxon	1D-16K-KF21X	£31.50
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Moon Shuttle	1D-16K-KF23A	£27.50
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A.E.	1D-48K-KF26D	£27.50
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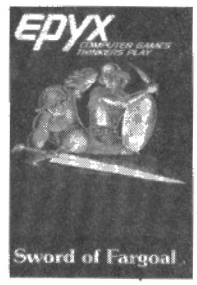

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Ghost Town with Graphics	1D-48K-KH03D	£28.95
Savage Island I with Graphics	1D-48K-KH04E	£28.95
Savage Island II with Graphics	1D-48K-KH05F	£28.95
Golden Voyage with Graphics	1D-48K-KH06G	£28.95
Curse of Crowley Manor	1C-16K-KH07H	£17.95
Escape From Traam	1C-16K-KH08J	£17.95
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3D Tic-Tac-Toe	1C-16K-KH11M	£10.95
S.A.G.E.: Pack also contains 48K version on Disk	1C-32K-KH12N	£35.95
The Eliminator	1C-16K-KH13P	£17.95
The Eliminator	1D-32K-KH14Q	£17.95
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Tank Arcade	1C-16K-KH18U	£11.95
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Telengard	1D-48K-KH22Y	£19.95
Moon Patrol	1C-16K-KH23A	£18.95
VC	1C-32K-KH24B	£14.95
VC	1D-40K-KH25C	£18.95
Book of Basic Adventures	Book	£14.50*NV*
Quick Reference Chart	Booklet	£1.99*NV*
Book of Hints	Book	£4.99*NV*

Commodore 64

Temple of Apshai	1D-BC57M	£27.45
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Curse of Ra	1D-BC59P	£13.80
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Crush, Crumble & Chomp	1D-BC61R	£20.75
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Junior Maths: Engineshed (+3K)	1C-BC99H	£4.99
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Sword of Fargoal (+16K)	1C-KK09K	£20.75
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Datestones of Ryn (+16K)	1C-KK13P	£13.80
Plattermania	1E-KK14Q	£27.45
Ricochet (+8K)	1C-KK15R	£13.80
Princess & Frog	1E-KK16S	£29.95
Ant Eater	1E-KK17T	£29.95
Typo	1E-KK18U	£29.95
Tank Arcade	1C-KH18U	£11.95

Note that some of the titles listed above will become available during the life of this magazine, so please check for availability.

JUPITER ACE IN OUR SHOPS NOW

For personal callers only, the incredibly fast Jupiter Ace microcomputer is now on sale in our shops (not available by mail order). The Ace uses the highly efficient Forth programming language. Excellently documented, easy to use and provides an economical method of learning this fascinating language. Price only £89.95.

CLASSIFIED

VARIOUS FOR SALE

C.B. RADIO Superstar 360, AM/FM/USB/LSB/CW high-mid-low bands, 5kHz shift. Built in SWR. Complete with antennae and mag mount. £120 ono. Phone West Drayton 47355.

NEW ICs packeted Tandy LS, TTL, LM series 90 total, 2 pre-amp stereo kits, list £24.95, mixer panel part built, list £69.95. Offers for lot. H. Catterson. Tel. 0642 821176.

SENSORY CHESS Challenger 9 for sale, £150. It won the 2nd World Microcomputer Chess Championship and has an official US rating of 1771! Tel (0302) 721456/49475.

TRANSCENDANT 2000 Synthesiser, £150; Minisonic Mk 2, £125. As new, built 2 DFMs £15 each. Ten boxes incomplete projects, kits, offers. Wayne Kerr LCR bridge, £25. Tel. Bridge 01-735 1862.

SOLARTRON DUAL Beam oscilloscope type CD-1400 15 MHz, spare plug-in modules, full working order, £70. Phone Graham, 01-651 5104 S. Croydon, Surrey.

30W VALVE AMPLIFIER, £5; record player, £5; 12in. speaker in double cabinet, offers; 'old' typewriter, £5; valves, £1 each. J. Weston, 47, Furnace Terrace, Pontyberem, SA15 5AE.

MUSICAL FOR SALE

I NEED to dispose of my matinee organ to make room for the next project. Any reasonable offer considered. Please telephone Dunblane 822841.

MATINEE ORGAN for sale, fully assembled and working, £300. Lincoln 20332.

TWO, 60 NOTE keyboards, £5 each. One 25 note R/C pedalboard £10; wood pieces to make suitable console, £5. Buyer collects. Taylor, Lutterworth (045 55) 2781.

MAPLIN MES53 organ, two 61 note manuals, short pedalboard, 50 stops, drawbars, MES55 auto rhythm, rotor sound, reverb, fully working, £700 ono. Phone Alan Perkin, Reading (0734) 883103 working hours.

MATINEE ORGAN, tested, ready to install in cabinet, £325 or exchange other electronic project. Telephone 'John' Wisbech (0945) 64805 evenings.

ORIGINAL MAPLIN MES 52 organ, two 49 note manuals, 13 note pedalboard, rhythm unit, attractive solid oak cabinet. Requires attention but has been working, £130 o.n.o. Burntwood 71594 evenings.

If you would like to place an advertisement in this section then here's your chance to tell Maplin's 140,000 customers what you want to buy or sell, absolutely free of charge. We will publish as many advertisements as we have space for. To give everyone a fair share of the limited space, we will print 30 words free of charge. Thereafter the charge is 10p per word.

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Please print all advertisements in bold capital letters. Box numbers are available at £1.50 each. Please send your advertisement with any payment necessary to: Classifieds, Maplin Mag, P.O. Box 3, Rayleigh, Essex SS6 8LR.

For the next issue your advertisement must be in our hands by 6th April 1983.

MAPLIN 3800 SYNTH. Fully built, tested and tuned. Complete with leads and manuals. Must sell, £250 o.n.o. Mr. J. Parkinson, 112, Oxford Road, Hartlepool, T52J 5RT.

MARSHALL 4-INPUT 100W valve amplifier + pair 2 x 12" Celestion columns £200 ono; WEM Copicat Echo, £50 ono, also microphones, stands, mixers, etc., part exchange? Felixstowe (Suffolk) 3994.

30 NOTE PEDALBOARD (radiating/conv.) £10; 30 K/A pedal jacks fitted series pots, wired 7 voices, £5; pair matching 61 note wooden manuals (angled fronts) £10 each; pair similar curved fronts, set (73) F/P chokes, A/D type C/T £10; set Ferrite chokes, Bobbins wound rocker switches, contact blocks. List with pleasure. Wolsey, Puffins. Seaview Lane, Seaview, I.O.W.

HI-FI FOR SALE

MAPLIN STEREO cassette deck kit, still in original box, £20 ono. Tel. Trowbridge 65245.

CRIMSON ELEKTRIK CPR1 preamp module with regulator PSU, and 2X CE1004 poweramp modules with instructions. All £40. Tel. Dave 051-426 5742.

COMPUTERS FOR SALE

ZX81 SOFTWARE. Four programs in fast machine code. Breakout 3K 3 levels, Hustle 2 levels, Othello 4k play the computer football 3k, £4 for cassette or s.a.e. For details to J. Hurley, 20 Dane Acres, Bishop's Stortford, Herts.

ATARI (VCS), 2 joysticks, 2 paddles, aerial switch box, adaptor and 4 cartridges (Space Invaders, Missile Command, Space Ware & Combat). Guaranteed till 5/7/83, only £90. R. Cyrus, 244, Latymer Court, Hammersmith Road, London, W6 7LB.

VIDEO GENIE EG3003 computer, 2 manuals, monitor, integral cassette recorder and 2 games, £230. Phone Crayford 528119.

ZX81 16K pools prediction program. Gives a 55 result prediction based on up to two years results. Lists any results, totally bombproof, on quality C12 cassette, £3.50. D. Allsopp, 206B, Corsham Road, Whitley, Melksham, Wilts.

ATARI EASTERN Front, 1941, 16k cassette, in its box with instructions, £18. Stanford-le-Hope (0375) 672077, after 5 p.m.

3K RAM PACK for VIC20 computer, brand new and unused, £18. Tel. Tony Pandy (0443) 437859 after 6 p.m.

WANTED

WANTED URGENTLY, instruction manual (or good quality copy) for Telequipment Serviscope Minor oscilloscope. G. Sage, 33 Barn Meads Road, Wellington, Somerset TA21 9BD. Tel. 6795.

WANTED GENUINE Leslie unit to install in organ cabinet. Would consider complete tone cabinet, exterior condition not important. Please contact Alford, 24 New Barn Lane, Alton, Hants. Tel. 84659.

WANTED, information on I.C.'s marked: 7214 KRE 1236-0574, 7215 KDO 1236-0590, 7215 KEU 1236-0582. Write 26 Clifford Road, Penrith, Cumbria, postage costs etc. (within reason) refunded. Any items loaned will be returned.

WANTED. Marble effect key tabs, flute 5⅓', flute 8', flute 4' (white), reed 4' (yellow). M. Alder, Laurel Cottage, Brewery Lane, Thrupp., Stroud, Glos. GL5 2EA. Tel. 0453 884451.

continued from page 47

THE STYLUS ORGAN VEROBOARD ASSY PARTS LIST

Resistors — All 0.4W metal film 1%

R1	4M7		(M4M7)
R3	56k		(M56K)
R4	560R		(M560R)
R5	10k		(M10K)
R6	18k		(M18K)
R7	3k3		(M3K3)
R8	47k		(M47K)
R9	12k		(M12K)
RV1	22k hor preset		(WR59P)
RV2	4k7 pot log		(FW21X)
RV3-28	100k hor preset	25 off	(WR61R)

Capacitors			
C1,C6,C7	100uF 25V axial electrolytic	3 off	(FB49D)
C2,3	100nF polycarbonate	2 off	(WW41U)
C4,5	22nF polycarbonate	2 off	(WW33L)
Semiconductors			
IC1,2	4046BE		(QW32K)
IC3	LM380N		(QH40T)
Miscellaneous			
S1	SPST sub-min toggle A		(FH00A)
B1	PP3 battery		
	PP3 connector		(HF28F)
LS1	Loudspeaker Ø66mm 64R impedance		(WF57M)
	Stylus lo cost test probe		(HF22Y)

needed for a single octave organ, and twenty-five are needed for a two octave type (this gives a complete scale including semitones in both cases). R2 enables the secondary oscillator to be set just off-tune from the main oscillator. The two oscillators will track with sufficient accuracy over a one or two octave range. R1 takes the control inputs of the oscillators to the negative supply potential and blocks oscillation when the stylus is not connected to one of the tuning presets.

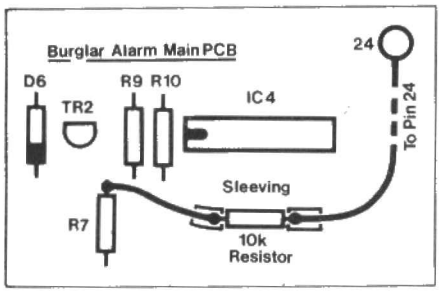
A simple passive mixer circuit is used to combine the outputs of the tone generators at the correct relative levels, and the signal is then taken via volume control VR1 to a simple audio output stage using an LM380N. This gives an output power of about 100mW RMS into a high impedance loudspeaker which should give adequate volume, but an 8 ohm speaker can be used if higher output power and volume are required. C4 and C5 are used to reduce the harmonic content on the output signal which is otherwise excessive due to the squarewave output signals from the tone generators.

The unit covers one octave either side of Middle C.

CORRIGENDA

On the frequency counter PCB (GB02C), two circles designating through pins have been omitted. One is situated just above R6, and the other is just below R6.

Owners of the Maplin Home Security System may be pleased to know that, with the addition of a minor modification, the requirements of British Standard 4737 can be met. Some insurance companies insist that systems be to this standard, so the modification is well worth fitting. With reference to the drawing, connect a 10k resistor, via a short length of wire, between pin 24 on the motherboard and the base connection of TR2. You may find it easier to connect onto the base resistor R7, just below TR2. Resistor R2 on the PSU PCB should be either shorted out or have a link connected in place of it.



ZX81 KEYBOARD MOD

For those who are experiencing difficulties connecting both keyboard ribbon cables to the ZX81 (Micro) PCB sockets — we stock two right angled connecting plugs.

a) RA LATCH MINICON PLUG 5 WAY (RK67X)

b) RA LATCH MINICON PLUG 8 WAY (YW18U)

Although these plugs are a latching type, the plastic latching section can be removed on both plugs and the ribbon cables soldered to the shorter ends. Insert the plugs into both PCB sockets.

When connecting up your ZX81 keyboard, always ensure that mains power is removed before plugging the adaptor L (RK27E) connector into the ZX81 and the keyboard. When all connections have been made, switch mains power on. When disconnecting the system mains power should be switched off prior to unplugging.

AMENDMENTS TO CATALOGUE

Please amend your 1983 catalogue as follows:

Page 25
The Aerial Rotator (XB54J) is not supplied with cable. Use 4-core mains (XR48C). Make no connections to terminal 2 of the controller. The wire from terminal 3 of the controller must be connected to terminals 2 and 3 at the rotator.

Page 66
The Snap-Together Plastic Boxes (YK48C, YK49D, YK50E, YK51F) dimensions stated are all internal.

Page 74
Laminate Aluminium large (XY20W) size is now 482 x 190mm (19 x 7½in).

Page 89
The sub-miniature single-ended electrolytic capacitor YY35Q is now only 35V working, not 40V as stated.

Page 99
The picture of the 2m Rubber Duck (YG15R) shows a UHF plug, but the item is supplied with a BNC plug as stated in the text.

Page 104
The Atari 400 (AF36P and AF37S) sound generators can only be 'piped' to a TV speaker. There is no DIN socket available for connection to an amplifier.

Page 122
BC44X (Computavoice) is a cassette, and BC36P (Cave Hunter) and BC38R (Starship Chameleon) are both cartridges.

Page 257
The Sharp stylus STY117 is the same as our stylus HR97F (Stylus Sanyo 2611), not BK08J as shown in our stylus guide.

Page 259
The High Quality Cassette Head Cleaner (BK28F) is now being supplied with a tape head cleaning stick and a 30cc bottle of tape head and capstan cleaning fluid.

Page 331
The 2732 EPROM (QQ08J) programming is achieved by applying +25V to pin 20 and +5V to pin 18, not pins 20 and 21 as stated.

Page 341
The mono headset (WF20W) is now terminated in a mono ¼in jack plug, not a 3.5mm jack plug as stated.

Page 374
The utility knife (FY02C) is shown incorrectly in the picture. This knife is NOT retractable.

Page 384
The overall size of the sub-miniature mains transformers (WB00A, WB01B and WB02C) is now 30 x 27 x 35mm, and fixing centres are 46mm.

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